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**DRAFT EXPERT REPORT  
OF  
DR. RICHARD L. DEGRANDCHAMP, Ph.D.**

**Regarding:**

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INITIALS Rly

**UNITED STATES DISTRICT COURT  
SOUTHERN DISTRICT OF OHIO, WESTERN DIVISION**

**UNITED STATES AND THE STATE OF OHIO**

**V.**

**AK STEEL**

**Civil Action No. C-1-00530**

**Prepared For:**

**U.S. Department of Justice  
Environment and Natural Resources Division  
Washington, D.C.**

**Dr. Richard L. DeGrandchamp, Ph.D.**

**University of Colorado**

**Scientia Veritas, L.L.P.**

**November 7, 2003**

**1 Introduction**

The United States has requested that I conduct a toxicological evaluation and analysis of human health risks associated with current and potential future exposure to polychlorinated biphenyl (PCB) contamination in Dick's Creek and Monroe Ditch resulting from uncontrolled releases from the AK Steel Facility, Middletown, Ohio. This report summarizes my opinion regarding the potential human health risks for developing cancer related to contact with the PCB contamination. Details of the toxicological/risk assessment procedures and results from my analysis are presented in the attached document, which is titled: *Human Health Risk Assessment For Dick's Creek and Tributaries, AK Steel, Middletown, Ohio*. I prepared this document at the request of EPA Region 5 with two main goals in mind, namely:

To determine if the contaminant levels of the highly toxic PCBs in Dick's Creek and its tributaries pose a sufficiently high threat to public health to warrant risk mitigation remediation; and

To determine if AK Steel is solely or partially responsible for releasing PCB contamination into Dick's Creek and its tributaries.

I reserve the right to supplement this report based on new information, data, or analyses I conduct.

## **2 Summary of Opinion**

I have quantified the human cancer risks associated with exposures to PCB contaminated sediments, soils, and fish to determine if the high levels detected pose a public health risk to the people in the local community. The following is a summary of my opinion regarding the human health risks:

Uncontrolled releases of PCB from the AK Steel facility have contaminated several miles of sediments, floodplain soils, and fish in Monroe Ditch and Dick's Creek; The volume and highly toxic form of the PCBs released from the facility have resulted in highly contaminated sediments, floodplain soils, and fish, and pose a significant threat to the public health for both children and adults who use the area for recreational activities; The PCBs that have been released from the AK steel facility contain a high level of a

particular group of highly toxic “dioxin-like” PCBs;

Exposure to PCB contamination in sediments, soils, and fish for nearby residents using Dick’s Creek for recreational purposes poses a very high cancer risk that exceeds  $1E-3$  (a 1-in-1,000 risk), which far exceeds health-protective levels;

Exposure to PCBs poses other non-cancer toxicological effects, including diabetes and immunotoxicity;

The highest cancer risk is associated with eating PCB-laden fish caught and eaten by local recreational fisherman (and their families), and the fish are likely to continue to be contaminated until the PCBs are removed from the sediments:

I have particular concerns about the toxicological effects associated with PCB exposures for sensitive subpopulations, including pregnant women, women of childbearing age in whom the PCBs can accumulate and be dangerously passed on to breast-feeding newborn children, those taking some medications for liver damage, and those suffering from immunosuppression;

Based on personal observations during a site visit and reports from experts at U.S. EPA and Ohio EPA, many people in the community are currently being exposed to the contaminated areas while engaging in wide-ranging recreational activities along the waterways of Dick’s Creek and its tributaries.

PCB congener data provides far superior information compared with Aroclor data for determining the nature and extent of contamination and quantifying human health risk; and

Based on archival Aroclor data, previous estimates of cancer risk made in several AK Steel documents have underestimated risk and the threat posed to public health primarily because the sampling and analysis used underestimates contaminant levels and concomitant risk.

Additionally, based on the background analysis and forensic fingerprinting study I conducted regarding parties responsible for the PCB contamination, I conclude:

The very low levels of PCB concentrations in the background area (upstream of the AK Steel facility) is significantly and statistically different from the downstream contaminated areas starting in the vicinity of where Sample S17 (at river mile 3.5) was collected;

There is only one unique PCB congener fingerprint identified in all contaminated sediments and floodplain soils downstream from Sample S17, which is very unique and completely different from upstream samples collected in non-impacted background locations;

The PCB fingerprint identified in all contaminated sediments is highly structured with very strong and consistent correlations between every PCB congener pair, with some pairs of congeners perfectly correlated, in contrast to the unstructured background PCBs; The PCB fingerprint for samples collected in Monroe ditch, which can only be attributed to the AK steel facility, perfectly matches the PCB fingerprints in all other downstream contaminated areas;

There is no evidence of third-party releases for several miles downstream of the AK Steel facility to the location where the S30 sample was collected (which did have a different fingerprint);

Unlike the unique fingerprint identified in contaminated samples, each background sample displays a different and random fingerprint (with no consistent structure among all background samples), which is typical in anthropogenic background conditions;

## **2.1 Qualifications**

### ***Education and Scientific Research***

I received a B.S. in biochemistry from Eastern Michigan University in 1978 and a Ph.D. in toxicology from the University of Michigan, School of Public Health, in 1986. After receiving my Ph.D., I received further postdoctoral training as a Rutgers Fellow in Toxicology at Rutgers University, Department of Pharmacology and Toxicology, and also held a joint appointment as a research associate at Cornell University School of Medicine, Department of Pharmacology, from 1986 to 1988, where I trained other toxicologists. I was awarded a National Institutes of Health Fellowship in Physiology at the University of Colorado School of Medicine from 1988 to 1991, where I conducted toxicology experiments and directed scientific training of numerous medical and graduate students in medical, environmental, and industrial toxicology.

I am currently an Adjunct Assistant Professor, University of Colorado Health Sciences Center, School of Pharmacy, Department of Molecular Toxicology and Environmental Health, Denver, Colorado, where I teach toxicology, risk assessment, and statistics to physicians and doctoral

candidates in toxicology. I have also been on the teaching faculty, Naval Civil Engineer Corps Officers School (CECOS), Port Hueneme, California, where I was responsible for developing risk assessment/management courses, toxicology, and statistics. I also teach classes in risk assessment and toxicology at the Navy Bureau of Medicine, Environmental Health Center, in Norfolk, Virginia.

I am President and Principal Toxicologist of Scientia Veritas, L.L.P., which specializes in risk assessment and management, industrial hygiene, toxicology, and occupational medicine. I have over 25 years of professional experience as a toxicologist and have conducted or reviewed over 300 human health risk assessments and toxicological evaluations relating to exposure to chemical contaminants very similar to the AK Steel site. My *curriculum vitae*, expert testimony provided in the last four years, and compensation I am receiving are presented in Attachment A.

## **2.2 Primary Sources and Documents Relied On**

*Human Health Risk Assessment for Dick's Creek and Tributaries*, October 2003, prepared by Dr. Richard DeGrandchamp for U.S. EPA Region 5 (attached as Attachment B).

National Research Council (NRC) 2001. *A Risk-Management Strategy for PCB-Contaminated Sediments*. National Academy Press, Washington, DC.

U.S. EPA 1996. *PCBs: Cancer Dose-Response Assessment and Application to Environmental Mixtures*. Office of Research and Development. EPA/600/p-96/001F. September 1996.

U.S. EPA 2001. *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites*. Peer Review Draft. Solid Waste and Emergency Response. OSWER 9355.4-24.

U.S. EPA 2000. *Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories Volume 1 Fish Sampling and Analysis, Third Edition* (EPA 823-B-00-007 2000).

U.S. EPA 1991. *Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions*. OSWER Directive 9355.0-30.

U.S. EPA 2003. Integrated Risk Information System (IRIS).

U.S. EPA 1991. *Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions* (OSWER DIRECTIVE 9355.0-30)

### 3 BASIS AND REASON FOR EXPERT OPINION

#### 3.3 Introduction

The human health risk assessment I conducted for Dick's Creek and Monroe Ditch is based on the most recent PCB sampling and analysis investigation conducted by U.S. EPA and Ohio EPA. U.S. EPA utilized the most sophisticated state-of-the-art analysis for PCB measurements based on EPA Method 1668 to quantify both total PCB and individual dioxin-like PCB congener concentrations. Although numerous previous samples have historically been collected and analyzed with "Aroclor" methods to determine the nature and extent of PCB releases, Aroclor data can only provide an approximation of contaminant levels. Moreover, Aroclor analysis frequently underestimates the levels of contamination. Therefore, my conclusions are based solely on the most recent PCB congener data, which are the most scientifically tenable data that most accurately represent the current levels of PCB contamination in Dick's Creek and its tributaries. Not only were older data based on flawed laboratory analytical methods for weathered Aroclor mixtures, but older data may also not represent current contamination conditions.

The PCB congener data provided all the necessary information to:

- Quantify cancer risks associated with exposure to dioxin-like PCB congeners; and
- To conduct a forensic fingerprint analysis to determine if AK Steel is responsible for all or some of the PCB releases in Monroe Ditch and Dick's Creek.

According to U.S. EPA guidance presented in *PCBs: Cancer Dose-Response Assessment and Application to Environmental Mixtures. Office of Research and Development*, as well as the more recent National Academy of Sciences, National Research Council's (NRC), scientific recommendations presented in *A Risk-Management Strategy for PCB-Contaminated Sediments*, PCB congener analysis should be performed at PCB-contaminated sites where Aroclors released into the environment may have undergone significant weathering. This is because Aroclor analysis can misrepresent contaminant conditions and result in underestimating the extent of

contamination. Furthermore, PCB congener data provides the necessary information to conduct sophisticated fingerprint analyses in order to determine responsibility for the release.

Verifiable environmental data for the most toxic constituents-namely, the PCB dioxin-like congeners-have been lacking. This important information must be considered because the carcinogenic potency (based on U.S. EPA's slope factors) for some of the dioxin-like PCB congeners is more than a thousand-times greater than that of non-dioxin-like PCBs. In addition, U.S. EPA guidance states that Aroclor data should *not* be used to quantify PCB-related risks at sites where PCBs have undergone weathering because PCB contamination can go undetected even though PCBs may be present in high concentrations. The analysis I conducted confirmed this problem. Using the recent sampling and analysis results, I directly compared Aroclor and PCB congener analytical data to show that Aroclor analysis has likely underestimated the total PCB contamination. In a sample-by-sample comparison (where the total PCB concentration in the sample based on Aroclor and PCB congener analyses were compared), I determined that Aroclor results for contaminated sediments underestimated contamination by 32% (see Exhibit 12 in Attachment B). The underestimation in fish was even greater where Aroclor analysis underestimated the level of contamination by 71% (see Exhibit 18 in Attachment B). Similarly, the most recent data provided by AK Steel showed that PCB homolog analysis also underestimates the amount of PCBs in sediments. On average, the PCB homolog results underestimated contamination by 77%. Since human health risks are proportional to the contaminant concentration, risks would have been underestimated by these same amounts had Aroclor or PCB homolog data been used in the risk assessment.

Although environmental samples were historically analyzed based on Aroclor analysis, there is now universal agreement that Aroclor analysis can lead to underestimating total PCB contamination. I recently provided expert testimony regarding numerous analytical problems with Aroclor data in a similar PCB contamination case in the Eastern District Court of Pennsylvania in *U.S. v. Union Corp.* where Judge Giles stated in his ruling:

"Finally, Dr. Anderson's quantitative risk assessment is likely to have underestimated the health risks from PCBs at the Site. Her risk calculations were based on existing data that reports PCBs in terms of commercial Aroclor mixtures, such as Aroclor 1254 and 1260. As explained by Government expert, Dr. Richard DeGrandchamp, and by other record evidence, there is an emerging scientific consensus that Aroclor analysis is prone to error in detecting

PCBs found in the environment. The Aroclor testing does not account for the likely presence of dioxin-like PCB congeners at the Site. Limited sampling in the mudflat sediments adjacent to the Site in June 2002 revealed the presence of dioxin-like PCBs along with Aroclor 1260.”

The other major problem with Aroclor analysis is that it ignores the most toxic components of PCB mixtures, namely the dioxin-like PCB congeners. Each Aroclor is a mixture of individual chemical called PCB congeners. Each Aroclor mixture can theoretically contain 209 individual PCB congeners (although only about 130 are typically present in most Aroclor mixtures). While the concentration of Aroclors in environmental samples can provide useful information in studying the extent of contamination at hazardous waste sites, the overall toxicity of environmental PCB mixtures is the sum of the individual toxicity of each PCB congener present in the mixture. Once released into the environment, weathering can dramatically alter the PCB congener composition of commercial Aroclors and, consequently, the toxicity. Therefore, to evaluate the toxicity and health risks associated with weathered PCB environmental mixtures, the amount of individual PCB congeners present in the sample must be quantified. Failing to do so can result in underreporting total PCB concentration. Judge Giles again made the following ruling on this matter in the U.S. v. Union Corp. case:

“Additionally, Aroclor testing tends to under-report PCB mixtures that have been exposed over time to weathering and degradation in the environment. The Aroclor testing of soils on the Property thus resulted in numerous ‘non-detect’ samples, which, upon closer analysis by Dr. Medine, were found to contain highly chlorinated PCB congeners.”

Another reason it is important to use PCB congener analysis is that Aroclor and homolog analysis cannot be used to detect the amount of the fraction of Aroclors containing highly toxic PCB congeners (see Exhibit 1 in Attachment B). For example, the carcinogenic potency of one of the dioxin-like congeners-namely, PCB 126) is approximately 15,000 times greater than the potency of “regular” or non-dioxin-like PCBs. Since human health risks are directly proportional to the chemical concentration, it is apparent risks can be significantly underestimated if the more toxic dioxin-like PCB congeners are simply ignored by using Aroclor analysis. Additionally, it should be noted that, because this group of PCB congeners is highly resistant to degradation, weathered PCB mixtures can actually be enriched in the amounts of the dioxin-like PCBs on a weight basis relative to the quantity of total PCBs.

Specific U.S. EPA guidance also highlights the shortcoming of Aroclor analysis and strongly recommends PCB congener analysis be conducted when quantifying human health risk. U.S. EPA risk assessment guidance states (U.S. EPA 1996):

“Although environmental mixtures are often characterized in terms of Aroclors, this can be both imprecise and inappropriate. Qualitative and quantitative errors can arise from judgments in interpreting gas chromatography/mass spectrometry (GC/MS), which reveals a spectrum of peaks that are compared with characteristic patterns for different Aroclors. For environmentally altered mixtures, an absence of these characteristic patterns can suggest the absence of Aroclors, even though some congeners are present in high concentrations.”

Accordingly, as noted in the U.S. EPA IRIS file (U.S. EPA 2003) for PCBs, congener analysis is important for the assessment of human health risks posed by a site:

“Although PCB exposures are often characterized in terms of Aroclors, this can be both imprecise and inappropriate. Total PCBs or congener or isomer analyses are recommended.”

U.S. EPA guidance is consistent with generally accepted toxicology practice, and the principle is consistent with the recommendations of the National Academy of Sciences, NRC, for conducting PCB analysis. In its discussion of methods of analysis of PCBs, the NRC (2001) states:

“Unfortunately, the environmental weathering of Aroclors modulates mixture toxicity (Quensen *et al.* 1998). As such, carcinogenic risk-assessment guidelines recommend the calculation of congener-specific or total PCB data when available (EPA 1994c). Congener-specific analyses utilize the direct quantification of each unique PCB congener. The result is a precise description of PCB profiles, which can highlight physiological, spatial, and temporal changes that might not be apparent in Aroclor values.”

In discussing some of the attempts to statistically “adjust” historical Aroclor data, the NRC states that even statistical manipulation cannot make up for the shortcomings in Aroclor data:

“Despite that, the Aroclor method does not adequately represent the concentrations found in weathered environmental samples. The discrepancies in the congener composition between

the commercial mixture and real-world environmental exposures imply that the predictive value of studies based on commercial mixtures might be limited with respect to estimating risks from environmental exposure.”

What NRC does strongly recommend is PCB congener analyses, stating (NRC 2001):

“Individual congener data provides the most flexibility for supporting environmental management decisions, because the congeners provide the raw data that can be analyzed numerically or statistically by the environmental manager, case by case, as needed... Congener-specific analysis is recommended for risk assessment because of the differences in the toxic potentials of individual congeners in technical mixtures.”

Without PCB congener data, human health risks cannot reliably be estimated. In the recent U.S. v. Union Corp. case Judge Giles, stated the following in his ruling:

“Dr. DeGrandchamp concluded that he could not reliably perform a quantitative health risk assessment due to the gaps in the existing data concerning the Site. However, on the basis of the existing data, especially the June 2002 sampling results that detected the presence of dioxin-like PCB congeners in the mudflats, he opined to a reasonable degree of scientific certainty, an opinion the court credits, that the Site Contamination presents, or may present, a significant potential threat to the health of two human populations: (1) people who consume fish caught in the Delaware River near the Site, and (2) future workers at the Site who may, if the Property is developed and PCB-contaminated soil is brought to the surface during excavation of foundations for new buildings, come into contact with the disturbed PCB contaminated soil.”

In the present study, U.S. EPA collected representative samples from the important environmental media, including sediments, floodplain soil, and fish tissue. U.S. EPA used state-of-the-art analytical procedures to show all three media are highly contaminated. As discussed in detail in Attachment B, PCB contamination in sediments and floodplain soils has been detected at 88 parts per million (ppm). Likewise, fish have been shown to be highly contaminated with PCBs at levels far exceeding screening levels used to protect and alert the general public against ingesting contaminated fish contaminated above health-protective levels. The high quality data that have been generated by U.S. EPA allowed me to estimate health risks much more precisely

than is possible with Aroclor or homolog data. The results of the risk assessment are presented in subsequent sections.

### 3.4 Toxicity of Dioxin-like PCBs and PCBs

The term “dioxin” refers to a group of compounds that are structurally similar; act through the same mechanism of toxicity (through the Ah receptor); and, ultimately, produce similar toxic effects. The group of PCB dioxin-like compounds that are of toxicological concern at the AK Steel facility are the 12 PCB congeners that produce the same toxic response as 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD), commonly known as dioxin. The inherent systemic toxicity and carcinogenic potential of dioxin-like compounds is based on a toxicity equivalency scale in which each individual dioxin-like congener is assigned a toxicity equivalency factor (TEF) based on the congener’s relative toxicity as compared with TCDD. TCDD is the most toxic congener and, accordingly, is assigned a TEF of 1.0. All other congeners have slightly lower TEF values, ranging from 0.5 to 0.00001. This toxicity-ranking scheme has been internationally endorsed and is universally accepted by nearly all toxicologists.

Dioxin-like compounds damage many parts of the immune system. Individuals accidentally or occupationally exposed to dioxin-like compounds have more skin and respiratory system infections, and middle ear infections. Workers exposed to high levels of dioxin-like compounds exhibit reduced T-cell activities; higher levels of IgA, IgG, IgM, and complement; and impaired immune responses. Dioxin also suppresses the immune system, compromising resistance to infections and developing cancers. Additionally, dioxin exposure impairs the thymus gland, which is a central component of the immune system and has been shown to undergo dramatic shrinking in young animals after dioxin exposure. For example, mice infected with influenza die at a higher rate if they are first exposed to a single dose of as little as 10 ng of dioxin per kg of body weight, which is a miniscule dose.

The toxicity of the herbicide “Agent Orange,” which was used in Vietnam, was due to the presence of dioxin. In an updated recent report, the National Academy of Sciences concluded that there is strong evidence of an association between exposure to dioxin and Type 2 (adult-onset) diabetes. Diabetes mellitus is a group of diseases characterized by high levels of blood glucose resulting from defects in insulin production, insulin action, or both. Diabetes can be associated with numerous serious medical complications and premature death. Numerous other

studies have linked dioxin exposure to diabetes. Dioxin-induced diabetes can lead to blindness, kidney disease, nervous disorders, blood circulation disorders, heart disease, and stroke.

Studies have also found dioxin to be a very potent carcinogen, producing soft-tissue cancers, non-Hodgkin's lymphoma, and Hodgkin's disease. Additional studies have found dioxin exposures are associated with cancers of the respiratory tract (larynx, lung or bronchus, and trachea) and prostate, as well as multiple myeloma.

Various regulatory agencies and scientific organizations have recently concluded dioxins are a known human carcinogen. For example, the National Toxicology Program recently upgraded the carcinogenic classification of dioxin from *Reasonably Anticipated Be a Carcinogen* to a *Known Human Carcinogen*. The International Agency for the Research on Cancer has also classified dioxin as a Group 1 or Human Carcinogen. The National Academy of Sciences' Institute of Medicine concluded "sufficient evidence of an association" between herbicides used in Vietnam and chronic lymphocytic leukemia (CLL). In response to this conclusion, Department of Veterans Affairs Secretary Anthony J. Principi has ordered the development of regulations that would add CLL to the list of illnesses presumptively recognized for service connection among Vietnam veterans (Secretary Principi states, "Compelling evidence has emerged within the scientific community that exposure to herbicides such as Agent Orange is associated with CLL...I'm exercising my legal authority to ensure the full range of VA benefits is available to Vietnam veterans with CLL.")

#### **3.4.1 PCB Toxicity**

Although the 12 dioxin-like PCB congeners (out of the 209 possible PCB congeners) produce highly toxic dioxin-like effects, the remaining PCB congeners produce non-dioxin-like effects through other toxic mechanisms, which are not mediated through the Ah receptor cells.

Toxicological studies have focused on wide-ranging types of PCB exposures, from those in the workplace to those in numerous poisoning episodes of the general population. For example, many Japanese citizens were poisoned in 1968 in an incident that occurred as a result of the accidental ingestion of PCB-contaminated rice oil. The most notable toxic symptoms in 189 patients included dark brown pigmentation of nails and skin, chloracne (acne like eruptions of the skin), increased eye discharge, increased sweating at the palms, and feeling of weakness.

Another massive poisoning occurred in China in 1979, where more than 2,000 people who ingested cooking rice oil contaminated with PCBs were affected. These individuals suffered liver damage and hepatomegaly (abnormal enlargement of the liver). The disease was especially severe in nursing children who were breast-fed or suffered fetal exposure *in utero* via exposed mothers. Developmental abnormalities have been observed in the brains (larger frontal and occipital fontanelles) of PCB-intoxicated infants. A significant correlation was found between plasma levels of PCBs in mothers occupationally exposed to PCBs in the workplace and the PCB in breast milk levels. It has been observed that if these mothers nursed their babies for more than three months, the PCB levels in the infants exceeded those of their mothers, and levels did not decrease for many years. This finding was an important consideration in my evaluation of AK Steep PCB exposures because fish caught recreationally and eaten by pregnant women of childbearing age could indirectly expose their newborns through breast milk.

U.S. EPA classifies PCBs as B2, or probable human carcinogens in humans. They have been shown to produce cancer in the livers of laboratory animals.

Due to the large differences in cancer potency, U.S. EPA PCB risk assessment guidance notes the importance of calculating both dioxin-like and nondioxin-like human health risks, stating (U.S. EPA 1996):

“When assessing PCB mixtures, it is important to recognize that both dioxin-like and nondioxin-like modes of action contribute to overall PCB toxicity (Safe, 1994; McFarland and Clarke, 1989). Because relatively few PCB congeners are dioxin-like, dioxin equivalence explains only part of a PCB mixture’s toxicity.”

Like U.S. EPA, the NRC strongly emphasizes the need for analyzing for PCB congeners to calculate risks associated with dioxin-like PCBs, stating (NRC 2001):

“The non- and mono-ortho-substituted PCBs are of particular concern, because these congeners can assume a planar or nearly planar conformation similar to that of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) (Safe 1990; Giesy *et al.* 1994a; Metcalfe and Haffner 1995) and have toxic effects similar to TCDD.”

### **3.5 Human Health Risks**

I conducted an HHRA associated with exposure to contaminated sediments, floodplain soils, and fish based on current PCB contaminant levels (however, it is important to stress that the current levels of PCB contamination will remain virtually unchanged because they only degrade and detoxify slowly, and it may take several decades for the concentration to be “naturally degraded” to health-protective levels).

In estimating the human health risk to those in the community who enjoy using Dick’s Creek for recreational activities, I first conducted an evaluation of how people could come into contact with PCB-contaminated media in Dick’s Creek and its tributaries, as well as the possible routes of exposure, magnitudes, frequencies, and durations of exposure. The primary goal of this step is to quantify the average daily dose of total PCBs and dioxin-like PCBs. The exposure assessment is based on the experimental paradigm developed by the National Academy of Sciences and further refined by U.S. EPA toxicologists and environmental scientists. Steps taken in the exposure assessment to quantify dose are as follows:

- Characterize the exposure setting and identify potential current and potential future human receptors;
- Identify complete exposure pathways and routes of exposure for each potential receptor;
- Estimate the exposure point concentration;
- Quantify chemical intake for individual exposure pathways for each potential receptor;
- and
- Combine chemical intakes across exposure pathways for each potential receptor.

The following equation and generalized exposure parameters are typically used to estimate human exposure conditions at Dick’s Creek (see Attachment B for more information):

$$\text{Intake} = C * CR * EF * ED * FI * (1/BW) * (1/AT)$$

I = Intake (milligram per kilogram body weight - day, [mg/kg-day])

C = Chemical concentration in contaminated medium (milligram per kilogram [mg/kg])

CR = Contact rate or ingestion rate (mg/day)

EF = Exposure frequency; how often exposure occurs (days/year)

ED = Exposure duration; how long exposure occurs (years)

BW = Body weight (kg)

AT = Averaging time; period over which exposure is averaged (days)

As part of the exposure assumption, I confirmed that the exposure assumptions were realistic by making a daylong site visit to Dick's Creek and personally observing evidence of human activity along the riverbank. I specifically looked for evidence of conventional recreational activities such as swimming, fishing, and hiking, and found evidence of all three.

Based on my observations, there are many residential communities along Dick's Creek that clearly use the creek for recreational purposes. Amanda school is also in close proximity to the creek, and there is clear evidence that there is considerable contact by students or school-age children. I observed well-worn footpaths along long the riverbank, apparently recently discarded fish parts in a large garbage plastic bag, and a tire swing apparently used to swing out and jump into the creek. There were also numerous foot and shoe prints up and down the embankments. Based on these observations, I concluded that the exposure assumptions were relevant and appropriate, and not merely "hypothetical."

For the purpose of the risk assessment, it was assumed that residents living in the communities along Dick's Creek would use the creek for recreational activities while they were residents in the local community, which is assumed to be 30 years (based on U.S. census data for a reasonable maximum exposed person). It should be noted, however, that exposures could last considerably longer than 30 years. This is because the 30-year residency assumption is for a person living in the *same home* for 30 years, but people often move to a *new home* in the same community. Therefore, a resident may use Dick's Creek for 30 years while residing in the same residence; however, if that resident simply moves several miles away into a new home, the resident would likely continue to use Dick's Creek for recreational purposes, albeit a different section of Dick's Creek. Nevertheless, this risk assessment was based on a 30-year exposure duration, which was used to represent the exposure period for a nearby resident visiting Dick's Creek for recreational purposes.

In order to calculate the daily chemical dose, I derived an exposure point concentration (EPC) to represent exposures in 2 separate sections of Dick's Creek. In deriving the EPC, the maximum detected concentration in each of the two sections was compared with the calculated 95% upper confidence limit on the mean concentration. The lower of the two concentrations was used as the EPC to avoid overestimating risk. I derived an EPC for sediments and soils, as well as for fish

that were caught. It should be stressed that analyzing actual fish tissue samples allowed me to make much more precise predictions of cancer risk associated with eating fish, because toxicologists often must use less precise mathematical models to estimate fish tissue concentrations.

I calculated the contaminant dose (chemical intake) for each age group-namely, child (aged 1 to 6) and adolescent and adult (aged 6 to 30 years) who would use Dick's Creek for recreation. Although there are numerous exposure pathways for different age groups, I reduced the risk assessment to focus on three main types of exposures, namely:

- Incidental ingestion of sediment and floodplain soil;
- Absorption of contaminated sediments and floodplain soils through the skin; and
- Eating PCB-contaminated fish.

Other exposure pathways (such as ingestion of contaminated surface water or absorption of contamination through the skin while swimming) would also pose risk and are also conventionally included in a human health risk assessment. However, I considered their contribution to the overall risk to be low and narrowly focused on the three exposure pathways of major health concern.

According to U.S. EPA guidance and good scientific practice, exposure parameters used to estimate contaminant intakes for a given pathway should be selected so that the combination of all intake variables results in an estimate of the reasonable maximum exposure (RME) for that pathway to ensure public health is protected. Standard default assumptions were used to estimate chemical intakes for each route of exposure (see Attachment B for details). For example, it was assumed that families (including children) would engage in recreational activities only during warm spring, summer, and fall months, for a total of 89 days per year. During those activities, children and adults would inadvertently ingest 200 and 100 soil and sediment per day, respectively. This type of exposure occurs through normal hand-to-mouth activities (I did not consider the more conservative pica child who is known to ingest 400 mg per day). I estimated that fish caught recreationally would be ingested by families, which included both children and adults at an average rate of 9 and 18 grams per day, respectively. However, it should be noted that a typical ingestion rate for consumption of fish caught recreationally is more than 50 grams per day. I reduced my estimate from this upper bound fish ingestion rate after my site visit, when

I concluded that 50 grams per day could tend to overestimate the risk. The rate I used is consistent with the ingestion rate used to develop fish advisories to warn fisherman not to eat contaminated fish. Finally, I assumed that one-half of the original fish PCB contamination detected in fish tissues would be lost through cooking as most recreational fisherman cook their fish before eating it.

In calculating cancer risk, I estimated risks for total PCBs, dioxin-like PCBs, and dioxin and furans separately. I did this in order to define risks that can be unequivocally attributed to AK Steel uncontrolled releases, which are the PCBs. That is, the fingerprint analysis I conducted to determine responsibility showed that there is no uncertainty AK Steel is totally responsible for PCBs detected in soil and sediments in Dick's Creek. However, the source of dioxins and furans is equivocal. Although it appears AK Steel has contributed to the dioxin and furan contamination, I could not determine the magnitude of the contribution. Therefore, I derived the cancer risk separately for PCBs apart from dioxin and furans. Exhibits 1 and 2 present a summary of cancer risk for the Area of Concern (AOC) 1 and 2, where I present the cumulative cancer risk for total PCBs and dioxin-like PCBs (excluding dioxin and furan risks). As detailed in Attachment B, I defined these two areas as appropriate and representative lengths of Dick's Creek where different individuals or different groups of recreational visitors would be exposed to different concentrations of PCB (see Exhibit 3 in Attachment B for additional information). AOC-1 extends from the vicinity of the Simpson Paper Mill upstream to a point just west of Yankee Road. AOC-2 begins at that point and extends upstream to a point about 100 yards downstream from Outfall 003. As shown in Exhibit 1, the reasonable maximum exposure cancer risk associated with PCB ingestion, absorption through the skin, and eating contaminated fish is  $3.8\text{E-}3$  for AOC-1. For AOC-2, the risk is even higher, at  $4.25\text{E-}3$ .

Risks associated with exposure to potential human carcinogens are estimated as the incremental probability of an individual developing cancer over a lifetime (even though the exposure duration is only 30 years while at the same residence) as a direct result of exposure to a chemical. The estimated risk is expressed as a unitless probability. For instance, a probability of  $1\text{E-}3$  represents the likelihood of one-in-one thousand developing cancer during a 70-year lifetime as a result of the defined exposure conditions when exposed to the chemical over a 30-year exposure period. To put the AK Steel cancer risk into context, it is more than 1,000 times the *de minimus* risk level representing no toxicological concern. Indeed, the cancer risk associated with exposure to PCB contamination in Dick's Creek far exceeds the U.S. EPA risk management level

where remediation is automatically triggered. As stated in U.S. EPA's (U.S. EPA 1991) long-standing risk management policy:

"Where the cumulative carcinogenic site risk to an individual based on reasonable maximum exposure for both current and future land use is less than  $10^{-4}$  (to the 4th power), and the non-carcinogenic hazard quotient is less than 1, action generally is not warranted unless there are adverse environmental impacts. However, if MCLs or non-zero MCLGs are exceeded, action generally is warranted...A risk manager may also decide that a baseline risk level less than  $10^{-4}$  (to the 4th power) is unacceptable due to site specific reasons and that remedial action is warranted."

Clearly the cancer risk levels for the AK Steel PCB contamination far exceed U.S. EPA's "bright line" cancer risk level of  $10^{-4}$ , which is the *minimum* level of public health protection. There are there are cancer risks associated with ingestion and dermal absorption from sediments and floodplain soils, but the greatest risk is associated with eating contaminated fish caught recreationally in Dick's Creek.

**EXHIBIT 1  
TOTAL AOC-1 CANCER RISKS FOR  
TOTAL PCBs AND DIOXIN-LIKE PCBs  
FOR RECREATIONAL EXPOSURE**

Type of Risk	Risk
Total RME Risk for Recreational Exposure	3.8E-03

**EXHIBIT 2  
TOTAL AOC-2 CANCER RISKS FOR  
TOTAL PCBs AND DIOXIN-LIKE PCBs  
FOR RECREATIONAL EXPOSURE**

Type of Risk	Risk
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I could not estimate the magnitude of non-cancer effects primarily because U.S. EPA (or any other scientific body or regulatory agency) has yet to develop non-cancer toxicity values for PCBs or dioxins that can be used to quantify the magnitude of non-cancer health effects. However, as was discussed previously, PCBs can also cause severe non-carcinogenic toxic effects, such as diabetes, liver disease, and immunotoxicity. I have concerns about non-cancer toxicity, and they should not be completely ignored in protecting public health. Another aspect that I did not consider is that newborn children may be highly exposed, and soon after birth, to AK Steel PCB contamination through breast-feeding. Women of childbearing age in the community who either fish themselves or prepare and eat fish caught recreationally by a family member will accumulate high levels of PCBs in fat-containing stores in the body—most importantly, breast tissue. Once PCBs are absorbed into the body's fat stores, it is not eliminated from the body for several decades.

AK Steel has asserted that “institutional controls” will effectively preclude exposures in the contaminated areas of Dick's Creek. However, the institutional controls they cite cannot be legally enforced at any part of Dick's Creek, particularly with regard to preventing recreational fishing, hiking, and swimming. Indeed, despite the common knowledge within the community that Dick's Creek is contaminated with PCBs, fishing is an ongoing recreational activity, as evidenced by the fish remains I observed during my site visit. According to U.S. EPA guidance (U.S. EPA 1989), risk assessments should not be conducted under the assumption institutional controls, such as “No Fishing Signs,” will be heeded by the community or be an effective deterrent for the young children or adolescents in the local community. It has been my experience at numerous heavily polluted sites that institutional controls will have little effect in protecting against human exposure because individuals simply become inured to verbal or posted warnings unless adverse health effects are severe and immediately noticeable, as they would be with other chemicals, such as a caustic chemical that would create a burning sensation. Unfortunately, PCBs—particularly, dioxin-like PCBs—act insidiously to produce severe toxic effects that only become manifest after a long latency period between exposure and toxicity. Finally, PCBs have no discernable odor or taste that could serve as a physical warning to recreational visitors who frequent the Dick's Creek area.

### **3.6 Comparison to Background Levels and Fingerprinting PCBs**

In addition to the human health risk assessment, I conducted a statistical analysis to determine if contamination in Dick's Creek downstream of the AK Steel facility was significantly different (higher) than upstream background levels. I also conducted a fingerprint analysis to determine if the contamination can all be attributed to AK Steel and whether there are any third party contributions.

The background analysis showed a high statistical difference between background levels of PCBs and PCBs downstream of sample location S17, which is approximately 100 yards from Outfall 003. There is a clear delineation between background PCB concentrations and PCB contamination downstream of Outfall 003 that can be attributed to AK Steel as shown in Exhibit 3. For example, the mean PCB concentration for the AK Steel-contaminated areas is more than 1,000 times higher than upstream non-contaminated background levels. When I applied the Wilcoxon-Rank Sum test to determine whether the two populations were statistically different, there was a high level of statistical difference between the two areas.

**EXHIBIT 3  
COMPARING TOTAL PCB SEDIMENT AND FLOODPLAIN  
SOIL CONCENTRATIONS IN CONTAMINATED AREAS TO  
BACKGROUND AREAS**

STATISTIC	DOWNSTREAM OF AK STEEL TOTAL PCB	
	BACKGROUND TOTAL PCB	
Number of Samples	26.0	4
Mean Concentration (ppm)	11.6	0.0052
Variance (ppm)	393	0.0000022
Standard Deviation (ppm)	19.8	0.0015
Minimum Concentration (ppm)	0.1	0.0035
Maximum Concentration (ppm)	88	0.0067

In addition to statistical tests, I applied the Spearman Rank Correlation statistical method to fingerprint the complex and weathered PCB mixtures. Fingerprints of commercial PCB

mixtures, such as Aroclors, have been relatively well characterized; however, after being released into the environment, PCB mixtures undergo weathering that alters the original composition, making the weathered fingerprint unique for the site conditions. Alterations in the original PCB mixture can be significant, as the composition of individual congeners in the released PCB mixture changes over time through partitioning and chemical transformation (dechlorination). That is, PCB congeners with similar physical properties will move through the environment and partition in different environmental media, and degrade at similar rates, resulting in the *ratio* of similar PCB congener pairs remaining constant as they migrate in the environment. When released into Dick's Creek, the ratio between similar congener pairs will remain constant even though the absolute concentration of each congener can vary considerably from one sample location to the next. Third-party sources can be identified readily with this fingerprinting approach because they will have a unique fingerprint that sets them apart because the original mixture was a different composition (i.e., different Aroclors) or it has undergone more or less weathering. Background conditions typically have a random fingerprint with no consistent characteristics. That is, the fingerprint is without structure because the overall composition of background is the sum of myriad and different PCB sources. Likewise, PCB mixtures from multiple sources will have an unstructured fingerprint because PCB congeners from different sources will not have a unique and individual fingerprint. In contrast to background and multiple sources, the PCB fingerprint from a single source is unique because the mixture is very homogeneous and highly structured.

To identify source areas and assign responsibility for the uncontrolled release of PCBs at the AK Steel facility and to determine whether there may be a third-party PCB release (unrelated to the AK Steel facility) in surrounding areas, I fingerprinted both the PCB mixtures in the AK Steel-impacted area and background, and compared the two. The fingerprints are markedly different (Appendix B, Attachment B). For example, Exhibit 4 shows that the fingerprint for the contaminated areas of Dick's Creek and tributaries is highly structured, with 45 out of a possible 45 congener pairs highly correlated; some of those are perfectly correlated, indicating a single unique source. Additionally, 45 out of 45 congener pairs have a correlation coefficient of more than 0.9, which represents an exceptionally high correlation index. In contrast, the PCB fingerprint for the background areas is unstructured, with no discernable pattern. Only 3 out of a possible 45 congener pairs are highly correlated. As previously noted, background conditions are typically random and without structure because the composition of PCBs in background areas is the result of numerous different PCB sources, which are typically the result of airborne

deposition.

**EXHIBIT 4**  
**COMPARISON OF CONTAMINATED AND BACKGROUND SEDIMENT**  
**PCB CONGENER FINGERPRINTS**

	Number of Correlated Congener Pairs Number of Pairs With $r \geq 0.9$	Number of Identical Matching Congener Pair Matches	
Contaminated sediments	45 (45)	3	45
Background sediments 3 (45)		1	

During the fingerprint analysis, I also statistically tested for the presence of third-party releases, which are easily identified with the statistical methods employed. The only sample that had a different fingerprint was sample S30 (see Exhibits 9 and 10 in Attachment B). This sample was collected miles downstream from the AK Steel facility near the Simpson Paper Plant, which may have been responsible for the release. However, the PCB concentration was very low in this particular sample. Other than this sample, all other samples collected in the contaminated area shared the same, almost identical fingerprint, including the PCB fingerprint in Monroe Ditch (which can only be attributed to the AK).

Although I also developed a fingerprint for dioxins and furan, the results were less clear as to the contribution of AK Steel releases to contaminated sediments. While the fingerprint for contaminated sediments does appear to be more structured than the background area, the AK contribution could not be quantified.

Based on the fingerprint analysis, I can make the following conclusions:

There is only one PCB congener fingerprint in contaminated sediments and floodplain soils downstream from sample location S17;

The PCB fingerprint in contaminated sediments is unique and highly structured, with very strong correlations between every pair, and some pairs of congeners are perfectly correlated;

The PCB fingerprint for samples collected in Monroe Ditch, which can only be attributed to AK Steel, is identical to the fingerprint in all other downstream contaminated

sediment samples, indicating AK Steel is responsible for all PCB contamination to at least the S30 sample location;

Unlike the contaminated PCB fingerprint, each background sample displays a different and random fingerprint, which is typical in anthropogenic background conditions that do not have a single defined source; and

The only sample in the contaminated area that was clearly identified as an anomalous sample in the PCB congener data set, indicating a potential "third-party release," is sample S30, which is located miles downstream and may represent a release from the Simpson Paper Mill.

## **ATTACHMENT A**

### **4 Compensation and Previous Testimony**

My billing rate is \$150.00 and \$170.00 per hour for litigation support and court testimony, respectively. In the last 4 years I have prepared expert reports and testified as an expert witness in the United States District Court, United States and City of Philadelphia V. Union Corporation, Metal Bank of America *et al.* Civil action no. 80-1589. I have also testified in the United States Bankruptcy Court Eastern District Of Missouri, Eastern Division, in the matter of Financial Services Group, Inc., *et al.*, In Proceedings Under Chapter 11 Case Nos. 03-45870-399, 03-46323-399 to 03-46327-399 03-46329-399 to 03-46350-399 03-46352-399 to 03-46354-399.

**5**

### **6 Curriculum Vitae**

**Dr. RICHARD L. DeGRANDCHAMP**  
*President and Principal Toxicologist*

#### **EDUCATION**

University of Colorado, Medical School, Department of Physiology, National Institutes of Health Postdoctoral Fellow, 1988-1991

Rutgers University, School of Pharmacy and Toxicology, Rutgers Postdoctoral Fellow, 1986-1988

Cornell University Medical School, Department of Pharmacology, Research Associate, 1987-1988

University of Michigan, School of Public Health, Ph.D., Toxicology, 1986

Eastern Michigan University, B.S., Biochemistry, 1978

#### **ACADEMIC APPOINTMENTS**

Adjunct Assistant Professor, University of Colorado, Health Sciences Center, School of Pharmacy, Department of Molecular Toxicology and Environmental Health, Denver, Colorado (May 1998-Current)

Teaching Faculty, Naval Civil Engineer Corps Officers School (CECOS), Port Hueneme, California (1996-2000)

#### **PROFESSIONAL POSITIONS**

March 1997-Current  
President and Principal Toxicologist, Scientia Veritas, L.L.P., Evergreen, Colorado

November 1996-March 1997  
Corporate Director of Medical Toxicology and Health Sciences and Principal Toxicologist, Terranext, Lakewood, Colorado

February 1996-November 1996  
Director of Toxicology and Risk Assessment and Principal Toxicologist, GeoTrans Inc., Boulder, Colorado

February 1992-November 1995  
Toxicology and Atmospheric Science Discipline Leader and Principal Toxicologist, PRC Environmental Management Inc., Denver, Colorado

May 1991-February 1992  
Senior Toxicologist, PTI Inc., Boulder, Colorado

1984-1986  
Consulting Toxicologist to EPA Neurotoxicology Division, Research Triangle Park, North Carolina

1980-1986  
Consulting Toxicologist and Research Assistant, University of Michigan School of Public Health, Department of Industrial and Environmental Health, Ann Arbor, Michigan

1978-1980  
Research Assistant, University of Michigan School of Public Health, Department of Water Quality

#### **PROFESSIONAL SOCIETIES/ASSOCIATIONS**

Society For Risk Analysis  
Society of Environmental Toxicology and Chemistry  
International Society of Environmental Forensics

## **SUMMARY OF PROFESSIONAL EXPERTISE**

Dr. DeGrandchamp is an expert in toxicology and risk assessment who has more than 23 years of professional experience. He has served on numerous scientific review panels and has been a toxicological consultant for: U.S. Environmental Protection Agency (USEPA), Department of the Navy (DON), Department of Energy (DOE), Department of Defense (DOD), Massachusetts Department of Environmental Protection as well as many chemical, pharmaceutical, and manufacturing companies. He has conducted or reviewed more than 300 human health risk assessments regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA; Superfund); Resource Conservation and Recovery Act (RCRA); and Underground Storage Tank (UST) programs. He has been the lead negotiator in over 200 regulatory meetings and provides expert witness testimony in toxic tort cases involving toxicological and medical claims resulting from toxic chemical exposure. He has also provided legal support on toxicological and risk assessment issues for EPA and has provided expert witness support for US Department of Justice in their expert witness unit on several cases. He has served on numerous expert scientific panel and authored guidance documents for conducting health assessments for USEPA, and the Navy Bureau of Medicine, Navy Environmental Health Center. He has recently developed policy and guidance documents for the Department of the Navy on conducting background analyses using correlation statistical analysis, conducting risk assessments for lead-contaminated sites, and conducting risk assessment/management investigations at PCB and dioxin contaminated sites.

## **TEACHING AND TRAINING EXPERIENCE**

Dr. DeGrandchamp is an Adjunct Assistant Professor at the University of Colorado Health Sciences, School of Pharmacy, Department of Molecular Toxicology and Environmental Health (DMTEH). He is responsible for developing and keeping current a comprehensive course on risk assessment and environmental toxicology course. He teaches this course to physicians and medical students in the Department of Preventative Medicine and Biometrics and doctoral candidates in the School of Pharmacy.

Dr. DeGrandchamp, as part of the teaching faculty at the Naval School Civil Engineering Corps Officers (CECOS) in Port Hueneme, California developed a risk assessment/risk management course that is taught throughout US at all Navy divisions.

Dr. DeGrandchamp develops and conducts 3-day workshops on risk assessment and toxicology for the Navy Bureau of Medicine, Environmental Health Center in Norfolk, Virginia.

Dr. DeGrandchamp teaches applied statistics for background analyses and Risk Based Corrective Action (RBCA) in the Navy CECOS *Advanced Environmental Restoration* training courses.

Dr. DeGrandchamp has instructed many U.S. EPA CERCLA and RCRA personnel, and Navy project managers in the practice and application of risk assessment, statistics, and toxicology at petroleum-contaminated site.

Dr. DeGrandchamp was responsible for training and mentoring many medical and toxicology graduate students during his postdoctoral tenure at three leading medical and graduate schools where he specialized in toxicology, physiology, pharmacology, and pathology.

## **SUMMARY OF TOXICOLOGICAL/RISK ASSESSMENT STUDIES**

Dr. DeGrandchamp has prepared a comprehensive risk assessment guidance document for conducting risk assessments at PCB contaminated sites for DOD. This document will be used to train all Navy personnel in conducting health-protective environmental studies to ensure Navy installations that will be returned to civilian use will not pose risk to public health.

Dr. DeGrandchamp developing the course curriculum for the risk assessment and risk management course for the Naval School Civil Engineering Corps Officers (CECOS), Port Hueneme, California. This course included state of the art instruction on: tiered risk-based screening, baseline risk assessment, statistical analysis, probabilistic risk assessment, toxicology, and bioavailability. These three-day courses were presented nation-wide at all the Navy Divisions.

Dr. DeGrandchamp is providing expert testimony and toxicology support to USEPA Region 8 and the Department of Justice for toxicological and risk-related issues pertaining to worker exposures at the largest polluting facility for the last 5 years. USEPA has requested his unique toxicological expertise to support USEPA injunctions, future litigation and enforcement orders.

Dr. DeGrandchamp is conducting a geostatistical analysis of background conditions for dioxin, furans, and PCB to which will be the standard background information repository to represent the Rocky Mountain Front Range for EPA Region 8. This analysis will be based on new method he developed based on geochemical analyses using linear regression and principal component analysis. This statistical analysis will be used to establish health-protective cleanup levels at sites in the Front Range and identify areas that may need remediation.

Dr. DeGrandchamp has recently developed and negotiated a geochemical method for evaluating background conditions in the state of Florida for the Department of Defense (Navy). After conducting a pilot study to demonstrate the geochemical technique can be used to define background conditions and identify chemical release areas, the Florida Department of Environmental Protection (FDEP) has formally approved the technique for use on Superfund and Federal Facilities throughout Florida. This background analysis is expected

Dr. DeGrandchamp is conducting a toxicological evaluation of human health risks at NAS Atsugi (Japan) for the Department of the Navy. This project involves developing toxicity values for 86 chemicals for which USEPA has not yet developed any toxicity information. This sole source project was triggered by the National Academy of Sciences recommendation to the Navy Surgeon General that a state-of-the art toxicological evaluation be conducted to determine if anecdotal reports of health effects can be substantiated. Dr. DeGrandchamp will develop toxicity values for these chemicals to determine whether all human health risks have been quantified.

Dr. DeGrandchamp was selected by USEPA to serve on an expert External Peer Review Panel to provide technical oversight for: "Draft Human Health Risk Assessment Protocols For Hazardous Waste Combustion Facilities And Screening Level Ecological Risk Assessment Protocols For Hazardous Waste Combustion Facilities." He was responsible for providing expertise in risk assessment and toxicology on the panel and participated in a 2-day public hearing/workshop to field and respond to public comments to prepare for finalization and release of the guidance.

Dr. DeGrandchamp was identified as the Technical Lead for EPA Region 6 in developing a new technical guidance document for RCRA sites: "Risk Management Strategy." He was responsible for all technical sections and responding to public comments.

Dr. DeGrandchamp is providing EPA Region 8 with toxicological and risk assessment technical support at two RCRA sites involving hazardous solvent exposure to off-site residents. He is responsible for evaluating risks and health hazards associated with vapor entering homes from contaminated ground water ground water into nearby homes. One of the most import issues he is resolving is whether formaldehyde, which has been detected in high concentrations, is emanating from contaminated groundwater or out-gassing from manufactured building materials. He is also responsible for evaluating current toxicological peer-reviewed toxicological studies on formaldehyde to identify current health problems in residents, determine acceptable levels of exposure, and identify homes that may require interim measures or evacuation of residents. His evaluations are multifaceted and must take into account all pertinent Environmental Justice concerns and potential toxic tort litigation.

Dr. DeGrandchamp is conducting a background analysis implementing "*Procedural Guidance for Statistically Analyzing Environmental Background Data*", which he authored for the Navy, at NAS Whiting (Milton Florida). This approach is being used to identify chemicals of concern for risk assessment, evaluate Applicable or Relevant and Appropriate Requirements (ARAR), and identify chemical releases. Successful completion of this project is expected to save DOD and the state of Florida \$30 Million in potential remediation costs.

Dr. DeGrandchamp has conducted a comprehensive review and analysis of diverse scientific methods used to evaluate risks associated with lead exposure for DON. He is preparing a white paper that will discuss the scientific veracity of the USEPA *Integrated Exposure Uptake Biokinetic Model* (IEUBK) software code, the California *Lead Spread Model*, and the new probabilistic *Integrated Stochastic Model* to make recommendations for improvement. He is also developing the DON risk assessment strategy to evaluate adult lead exposure to expedite lead cleanup at closing Naval installations.

Dr. DeGrandchamp has developed a cost-effective, risk-based corrective action approach for a hazardous waste site for Lockheed Martin in Denver, Colorado. The approach incorporated Monte Carlo simulation techniques to accurately estimate actual site-specific risks based on realistic exposures. A cost-benefit matrix was being developed to guide risk management decisions.

Dr. DeGrandchamp is providing toxicological expertise to USEPA and overseeing all risk assessments at several RCRA facilities in the Denver, Colorado area. Groundwater contaminated with chlorinated solvents has migrated offsite and has been discovered to be migrating into homes through their basements. He has been requested to evaluate the residents health and determine risks as well as participate in risk mitigation activities.

Dr. DeGrandchamp is authoring risk assessment guidance for the Navy Environmental Health Center. He is responsible for developing novel approaches to evaluate risks and health hazards.

Dr. DeGrandchamp provided technical expertise on wide-ranging issues to EPA Regions 8 and 6 RCRA and CERCLA programs. He provided toxicological and statistical support on all remedial investigations and feasibility studies conducted at Rocky Flats Nuclear Weapons Plant (RFP) and was involved in all investigations pertaining to the analysis of human health risks resulting from chemical and radionuclide exposures. He developed data quality objectives and risk assessment methodology, statistical analysis, sampling and analysis plans, and oversaw all chemical and radiological fate and transport modeling. He compiled a database for conducting Monte Carlo simulations and provided technical review on supplemental guidance for conducting Monte Carlo simulations for EPA Region 8. He developed a cost-effective risk assessment template for RFP to streamline and provide consistency for all risk assessments. Dr. DeGrandchamp was responsible for evaluating DOE's statistical analyses and risk assessments and ensured results were consistent with USEPA, the International Commission on Radiation Protection (ICRP) and Nuclear Regulatory Commission (NRC) methodologies. He assisted EPA Region 8 in negotiating numerous disputes and was a participant in a workgroup of nationally recognized experts in binding arbitration involving statistical analyses. He was selected as a member of an interagency committee that included the Colorado Department of Natural Resources, Colorado Department of Health, Colorado Fish and Wildlife Service, EPA Region 8, and DOE to scope, design, and implement a comprehensive installation-wide human health and ecological risk assessment for Rocky Flats.

Dr. DeGrandchamp provided scientific expertise to DOE on toxicological, risk assessment, and statistical issues at the Savannah River Site (SRS) in South Carolina. He reviewed human health risk and dose assessments conducted for numerous operable units and participated on a task force responsible for establishing background conditions. He was invited to lecture on risk assessment and statistical issues by EPA Region 4, DOE, and the South Carolina Department of Health project managers and toxicologists.

Dr. DeGrandchamp conducted numerous baseline risk assessments at Naval Air Station (NAS) Lemoore in California. These risk assessments were ultimately combined into a comprehensive installation wide risk assessment that involved fate and transport modeling of contaminants coupled with the analysis of current and potential future health risks. He was responsible for all negotiations with federal and state regulators. He successfully negotiated cost-effective management of human health risks during remedy selection by using a risk-based approach to avoid unnecessary and expensive remediation

Dr. DeGrandchamp conducted all risk assessments and coordinated feasibility studies for NAS Moffett Field in California. He carried out a detailed future land use analysis that was used to focus risk mitigation strategies based on probable future land use. The land use analysis was also used to focus human health risk assessments on realistic exposure

conditions to avoid unrealistic conservative default assumptions. He negotiated all aspects of the risk assessment approach with state and federal regulatory agencies. The Navy requested Dr. DeGrandchamp to assist the Department of Justice to avert formal dispute resolution.

Dr. DeGrandchamp conducted risk assessments for NAS Alameda in California. He was responsible for developing the overall risk assessment approach and negotiating all technical aspects of the project Navy with local, state, and federal regulators. He was also tasked with preparing innovative approaches to establish anthropogenic and nonanthropogenic background conditions, preliminary remediation goals, and data aggregation to estimate exposure-point chemical doses. He was also responsible for developing a Navy policy document for risk-based corrective action (RBCA) at petroleum sites.

Dr. DeGrandchamp provided oversight to DOD for risk assessments conducted for NAS China Lake. He was responsible for implementing a risk-based cost-effective approach for remediation and alternative cleanup levels based on actual site exposures.

Dr. DeGrandchamp provided technical expertise to the Massachusetts Department of Environmental Protection for radionuclide risk assessments, compliance, and cleanup standards. He worked with the state to develop state guidance for radionuclide cleanup of all Department of Defense and Nuclear Regulatory Commission operated sites within the state.

Dr. DeGrandchamp provided EPA Region 8 with technical oversight for all remedial investigations and risk assessments for F.E. Warren Air Force Base in Wyoming and Tooele Army Depot in Utah. He conducted a risk assessment in response to an emergency exposure condition for off-site residents at F.E. Warren AFB who were directly exposed to high concentrations of organic solvents.

Dr. DeGrandchamp led the human health and environmental risk assessment task force for EPA Region 6 in studying potential adverse health effects associated with emissions from several incinerators in Midlothian, Texas. This investigation was prompted by strong public concern about adverse health effects on humans and livestock. In this evaluation, Dr. DeGrandchamp analyzed the potential for dioxin to produce birth defects, spontaneous abortions, and other potential toxic effects.

Dr. DeGrandchamp investigated the human health risks associated with RCRA facilities in southern California. He conducted the risk assessment for the onsite human receptors as well as the surrounding community to determine the potential risks to pregnant woman from benzene, arsenic, and cadmium exposure in groundwater. He also evaluated the risks to fetuses via *in utero* exposure. At another RCRA facility, he conducted a risk analysis to determine potential risks associated with arsenic-laden fly ash used as landfill material.

Dr. DeGrandchamp provided oversight and technical support to the EPA Region 8 (Montana office) RCRA division for remediation of oil refineries in Billings, Montana, Mandan, North Dakota, and Commerce City, Colorado. He oversaw all phases of the RCRA process involving preliminary investigations and corrective measures studies. His developed health-protective cleanup levels, and evaluated facility permitting and remediation enforcement. Together with Colorado Department of Health officials, he worked to negotiate remediation goals and a cost settlement.

## LITIGATION EXPERTISE

Dr. DeGrandchamp was an expert witness for the United States Department of Justice in District Court, E.D. Pennsylvania. United States of America, v. Union Corp.; Metal Bank Of America; Irvin G. Schorsch, Jr.; And John B. Schorsch. V. Consolidated Edison Co. Of New York; Public Service Electric & Gas Co. Of New Jersey; And Monsanto Co. No. Civ.A. 80-1589. He provided expert testimony on the human health risks associated with two PCB and dioxin contaminated sites in Pennsylvania. He provided expert reports, rebuttal reports, and supplemental reports, depositions, interrogatories, and assisted USDOJ in preparing for depositions. Based on Dr. DeGrandchamp's testimony that the chemicals posed unacceptable health threats, the court has ruled completely in DOJ's.

Dr. DeGrandchamp was an expert witness for the United States Department of Justice in United States Bankruptcy Court, Eastern District Of Missouri Eastern Division In The Matter Of: Union Financial Services Group, Inc., Et Al. Debtors In Proceedings Under Chapter 11 Case Nos. 03-45870-399, 03-46323-399 To 03-46327-399, 03-46329-399 To 03-46350-399 03-46352-399 To 03-46354-399. This was a bankruptcy trial in which the trial judge ruled in USDOJ'S favor and required the PRP to secure a multimillion-dollar holding to remediate PCB contamination to mitigate health risks to acceptable levels based on Dr. DeGrandchamp's testimony.

Dr. DeGrandchamp is the expert toxicologist for USDOJ for a magnesium manufacturing facility in Utah, which has been the number polluter in the US for several years. He is responsible for conducting toxicological evaluations on worker's health, reviewing medical records, and evaluating health threats to workers at the facility associated with exposure to hexachlorobenzene, dioxins, PCBs, arsenic, and chlorine gas. He is preparing expert reports, providing depositions, interrogatories, and assisting USDOJ to prepare for depositions, and taking testimony from the defendant's experts on issues relating to human health risks and toxicological issues.

Dr. DeGrandchamp has provided expert testimony representing the City of Platteville regarding public health threats and risk associated with bacterial infection from livestock in the state of Colorado. He developed the overall scientific strategy for evaluating the risks and potential health threats to residents from agricultural chemicals and the mutant strain of *Escherichia Coli* 0157:H7.

Dr. DeGrandchamp has provided expert litigation support in several toxic tort litigation cases for a potentially responsible party at a chrome-plating facility in Texas. His responsibilities include reviewing medical records, preparing pretrial reports, giving depositions, presentations during arbitration and mediations, preparing trial exhibits, preparing guardian *ad litem* documents, and testifying at trials.

Dr. DeGrandchamp has assisted the US Navy DOJ attorneys on diverse health and environmental issues. Dr. DeGrandchamp provided DOD with technical expertise and negotiation support in their Navy CLEAN program. He is a member of a program-wide technical panel that evaluated the legal basis for developing innovative remediation strategies to streamline the CERCLA process for all Navy bases scheduled for closure or transfer. He prepared position papers, developed the Navy's overall remediation strategy; and negotiated with local, state, and federal regulation agencies. He has been the technical expert in numerous negotiations and dispute resolution meetings.

Dr. DeGrandchamp served as the toxicological expert in a toxic tort case filed against a major pesticide manufacturer that involved domestic exposure to a pyrethroid pesticide.

After evaluating exposure conditions and reviewing medical records he determined the case lacked merit. Defense attorneys were subsequently successful in having the case dismissed.

Dr. DeGrandchamp provided litigation support for a toxic tort case involving a PRP in Montana involving exposure to petroleum constituents. His responsibilities included developing the overall scientific strategy and designing a sampling plan for the defense.

Dr. DeGrandchamp provided legal support for a chlorinated solvent site in Montana. He also served as the technical advisor on community relations for this project. He was responsible for interacting with the U.S. Department of Health and Human Services, Agency for Toxic Substances and Disease Registry (ATSDR).

## **BIOMEDICAL RESEARCH**

Dr. DeGrandchamp investigated the neurotoxic mechanisms associated with exposure to mercury and acrylamide. This information was incorporated into the toxicological database developed by USEPA and the Occupational Safety and Health Administration to set regulations and establish safe exposure conditions for occupational workers.

Dr. DeGrandchamp investigated the neurotoxic effects of alcohol on the developing nervous system, which produces fetal alcohol syndrome. He was responsible for developing new research methodologies and approaches to investigate subtle molecular changes in the nervous system.

Dr. DeGrandchamp designed experimental paradigms to study the bioavailability of mineralogical forms of heavy metals, such as arsenic and cadmium, from mining tailings for a CERCLA site in Montana.

Dr. DeGrandchamp worked on a project for the National Institutes of Health to investigate the neurophysiological mechanisms of strychnine poisoning. In this capacity, he coordinated a team of experts and managed all technical personnel in a multifaceted research program to elucidate the steps that result in central nervous system damage.

Dr. DeGrandchamp further refined the neurotoxic esterase *in vivo* enzyme assay used to evaluate neurotoxic damage resulting from nerve agents and pesticides. This laboratory method has become a standard methodology to screen neurotoxic compounds in the chemical industry and to evaluate the neurotoxic potential of chemical weapons. He also developed a correlative animal model for USEPA to quantify chemical-induced neuropathies associated with exposure to pesticides and nerve agents.

## **PUBLICATIONS**

Dr. DeGrandchamp has authored over 100 human health proprietary risk assessments and toxicological evaluations.

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UNITED STATES DISTRICT COURT  
*FOR THE S.D. OF OHIO*  
UNITED STATES ~~AND STATE OF OHIO~~ *et. al.*  
V.  
AK Steel Corporation (Middleton Works)  
Civil Action No. C-1-00530

EXPERT REPORT  
OF  
Allen J. Medine, Ph.D, P.E., DEE

Prepared for  
U.S. Department of Justice  
Environment and Natural Resources Division  
Washington, D.C.

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Allen J. Medine, Ph.D., P.E., DEE  
Water Science and Engineering  
900 Valley Lane  
Boulder, CO 80302

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September 19, 2003

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**EXPERT REPORT**  
**ALLEN J. MEDINE, Ph.D., P.E.**  
**AK Steel Corporation (Middleton Works)**

**SECTION 1.0**  
**INTRODUCTION**

**1.1 PURPOSE OF REPORT**

This report has been prepared to present conclusions concerning the analysis of environmental samples for the presence of polychlorinated biphenyls. This report describes the definition of Polychlorinated Biphenyls, the definition of Aroclors, the composition of Aroclor mixtures, the methods for PCB analysis (Aroclor, Homolog and congener analysis), example application to environmental data and limits to interpretative tasks using AROCLOR analysis. ~~The report stresses~~ that congener analysis is the preferred approach for characterizing contamination of environmental samples for total PCBs and well as individual compounds and that congener analysis is more precise, reliable than Aroclor or Homolog Analysis and that non-congener analyses will underestimate the total PCB content of environmental samples.

**1.2 QUALIFICATIONS OF DR. ALLEN MEDINE**

**1.2.1 Education and Professional Registrations.** I received a Bachelor of Science degree in Civil Engineering from the University of Illinois, Champaign-Urbana in 1972, a Masters Degree in Civil/Sanitary Engineering (the predecessor to the Environmental Engineering program) from the University of California, Berkeley, in 1973 and a Ph.D. in Environmental Engineering from Utah State University, Logan, in 1980. I have a minor in Chemistry for my doctorate. I am a registered Professional Engineer in Colorado (P.E. #29856) and am a Diplomate Environmental Engineer (DEE) in the American Academy of Environmental Engineers (AAEE) with a Hazardous Waste Specialty certification.

**1.2.2 University Research and Teaching Experience.** I have been involved in education for 30 years, initially as a faculty member at the University of Connecticut and the University of Colorado-Boulder and recently through presenting workshops, teaching classes and presenting seminars at CU-Boulder, CSU and the Colorado School of Mines. My responsibilities at both the University of Colorado and at the University of Connecticut included teaching graduate and undergraduate level courses, environmental engineering research, and student supervision. Additionally, I was responsible for organization and maintenance of the environmental engineering chemistry laboratories. I developed, implemented and managed environmental engineering analytical laboratories for research programs at the University of Connecticut and the University of Colorado for 7 years as a faculty member in the Civil and Environmental Engineering Departments. I have served as a major advisor for 6 graduate students (M.S. & Ph.D.) and have been a committee member for over one dozen Ph.D. Candidates and 30 Masters

Candidates in the fields of Civil & Environmental Engineering, Chemistry, Biological Sciences, Agricultural Engineering and Geological Sciences. Graduate level courses taught at Colorado State University, Univ. of Colorado-Boulder, and at Univ. of Connecticut-Storrs while on the faculty included

- Aquatic Chemistry (environmental, process, geochemistry, chemical modeling)
- Fate and Effects of Pollutants and Hazard Assessments
- Environmental Chemical Analysis Methods
- Hydrologic Simulation Methods in Environmental Engineering
- Contaminant Transport & Transformation Modeling
- Unit operations and Processes Pilot Plant Laboratories
- Wastewater Treatment / Design and Theory
- Advanced Wastewater Treatment / Design and Theory
- Advanced Water Treatment / Design and Theory
- Industrial Waste Treatment

**1.2.3 Professional Experience.** I have 30 years of professional experience in civil/environmental engineering and environmental chemistry, including the previously mentioned teaching and research experience. I have worked on a wide variety of civil/environmental engineering and environmental science projects, and provided a wide range of technical support at over two dozen Superfund sites, including litigation support on 10 Superfund projects and expert testimony in federal court. I have been committed to technology transfer and research in environmental management and have taught technical workshops on modeling for toxics & conventional pollutants, environmental and analytical chemistry, permitting and methods for meeting standards, innovative treatment technologies, analysis of contaminant loadings, and environmental impacts of pollutants in natural systems. My expertise includes evaluating contaminant source loading from industrial facilities, watershed management and restoration of damaged ecosystems, and behavior of toxic substances in the environment. Currently, I am a principal engineer and owner of Water Science and Engineering in Boulder, Colorado.

As a technical director for a large commercial laboratory, I developed a <sup>of</sup> internal peer review program to perform Quality Assurance / Quality Control (QA/QC) ~~fall~~ data leaving the laboratory, including data developed for EPA's Contract Laboratory Program (CLP) as well as for industrial clients for metals, volatile and semi-volatile organics, pesticides and other parameters.

I was the project manager and senior environmental engineer at over two dozens CERCLA sites involving a full range of field operations designed to gather information for remedial technology application toward site cleanup. I am thoroughly familiar with the CERCLA process from site characterization through and including remedial design/remedial action. My field operation expertise includes site assessments, risk assessment, development of monitoring programs, contamination delineation, bioassessments, health & safety plans, sampling and analysis plans as well as analytical data validation, reduction and interpretation. I have used numerical contaminant transport modeling in conjunction with GIS systems to integrate vast quantities of environmental data to evaluate waste treatment location/volumes, transport pathways, soil

erosion, sediment and floodplain dynamics and historical, remedial action effectiveness, and natural contaminant sources.

I have provided technical support to the U. S. government on a variety of hazardous waste sites that are similar in nature to the AK Steel Site in that there are multiple contaminant types and a variety of disposal source areas. They are described briefly below:

**Weldon Spring Site Remedial Action Project, MO**

DOE Installation-Mixed Waste: U, Th, Ra, Rn, TNT, DNT, PCBs, toluene, metals; Managed technical aspects of site characterization for Remedial Investigation and provided senior support on risk assessment, analytical data validation, and applicable technologies for remedial action, all environmental media.

**Metal Bank Superfund site, PA**

Transformer dismantling and waste oil disposal, complex waste site, metals, organics, solvents; Evaluated fate and transport of PCBs, PAH, Dioxins/Furans in soils, groundwater, river sediments, developed sampling and analysis plan for PAH, Dioxins/Furans, PCBs (congeners, homologs and Aroclors) in support of site characterization for remedial action determinations.

**Sheridan Disposal Services Superfund Site, TX**

Multiple PRP organic waste disposal site: PCBs, metals, benzene, ethylbenzene, phenanthrene, TCE, and numerous others; Project Manager for technical oversight of treatability studies, FS, Remedial Design and Remedial Action and technical negotiations.

**Champion International Superfund Site, Libby, MT**

Wood products treating: Pentachlorophenol, PAHs; Technical review of design of Land Treatment Disposal Unit for biological degradation treatment of soils, QA/QC and No-Migration Petition.

**Lowry Landfill Superfund Site, CO**

Complex waste site, metals, organics, solvents; Evaluated CERCLA Action, environmental contamination, leachate formation processes, environmental regulations and commonly used disposal practices, wastewater treatment technology, sludge generation and quality.

**Fike/Artel Superfund Site, WV**

Complex chemical manufacturing site, metals, organics; Evaluated fate and transport of toxic substances, assessment of historical releases of hazardous substances and allocation methodology.

**Arlington Packaging and Blending Site, TN**

Chemical manufacturing site: arsenic, chromium, selenium, pesticides, solvents, pentachlorophenol; Evaluated source, fate and transport of toxic substances, soils, groundwater and surface water contamination, remediation technology assessment and divisibility.

**Elmendorf Air Force Base, AK**

Fuels; Technical support on quality assurance, analytical requirements, bioremediation, and data needs for treatability studies and construction of bioremediation facilities for contaminated soils.

**Chemplex Superfund Site, KS**

Multiple PRP organic waste disposal: metals, benzene, ethylbenzene, phenanthrene, TCE, and numerous others; Senior engineer for contractor oversight for treatability studies involving, stabilization/solidification (S/S), solvent extraction, bioremediation, incineration, air stripping and thermal degradation.

**Krejci Dump Site, OH**

Metals, PCBs, solvents, dioxins/furans. Evaluated analytical chemistry and contaminant source, transport and fate.

**ASARCO Globeville Facility, CO**

Metal smelter, cadmium, arsenic; Evaluated environmental chemistry (surface water, groundwater, soil), environmental effectiveness of remedial technologies, engineering technology for hazardous waste remediation, natural resource damage assessment, field investigation of soils, sediment and surface water contamination.

I have published over two-dozen technical papers and prepared in excess of 50 technical reports on a variety of environmental engineering topics. I have also presented numerous seminars, invited papers and technical papers at national and international conferences and symposia and chaired sessions at various conferences. I have been a reviewer of technical papers for Water Research (IAWQ), ASTM, USEPA, National Research Council, ASCE and various publishers and prepared questions, evaluated written and oral examinations for professional licensure of other professionals through NCEES and AAEE. My resume is attached as Appendix A

**1.3 DOCUMENTS RELIED ON, EXHIBITS AND RESERVATION OF RIGHTS**

✓ The data relied upon includes reports, documentation, maps and analytical data referenced in this report, as prepared for the ~~GERCLA~~ <sup>BCRA</sup> activities at the site or collected as part of on-going data collection activities at the site. I may use at trial any documents, figures, tables, maps or photos which I have relied on in this report or in any supplements to this report. I understand that discovery in the case is continuing, and as such, I am continuing to gather and interpret additional data and new information. I reserve the right, as permitted by the Federal Rules of Civil Procedure, to supplement and modify my opinions or bases of my opinion, as needed to fully express my opinion concerning the issues presented in my report, to respond to supplements of other expert reports produced in the case, and to respond to new information obtained through depositions of other expert witnesses.

**1.4 COMPENSATION AND OTHER TESTIMONY**

I am billing the Department of Justice at the rate of \$ 163.00 per hour for litigation support and technical work. Trial testimony and deposition testimony is billed at \$ 244.50. I have provided expert witness and litigation support on over ten major hazardous water sites in areas such as waste characterization, sampling and analysis, analytical chemistry, contaminant source, transport, transformations, fate, environmental regulations and remedial technology.

The cases for which I have testified in Deposition or Trial in the preceding four years are as follows:

<b>Case</b>	<b>Site</b>	<b>Deposition</b>	<b>Trial</b>
U.S. Gov. v. Union Corp., et al.	Metal Bank Site (bankruptcy)	-	2003
U.S. Gov. v. Union Corp., et al.	Metal Bank Site (liability)	-	2002
Newmont v. Versar	Hoge Mine Site	2001	-
U.S. Gov. v. Chrysler Corp. et al.	Krejci Dump Site	2001	-
U.S. Gov., State of CO v. Friedland	Summitville Mine Site	2000	-
State of Colorado v. D'Angelo	RCRA Ni-Cd Battery Storage	2000	2000
C. DeBaca et al. v. ASARCO, Inc	ASARCO Globeville Facility	1999	1999
City of Lakewood v. Quality Metal	Groundwater Site	1999	-

SECTION 2.0  
SUMMARY OF OPINIONS

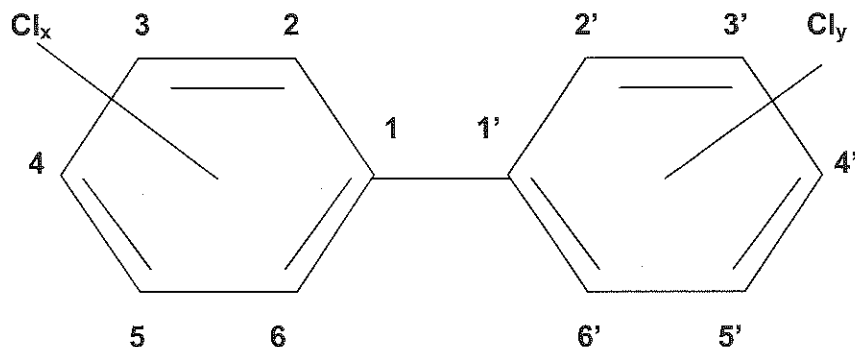
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## SECTION 3.0 ENVIRONMENTAL AND ANALYTICAL CHEMISTRY OF PCBs

### 2.1 PCBs ARE SYNTHETIC INDUSTRIAL ORGANIC CHEMICALS

PCBs are polychlorinated biphenyl compounds that have been widely used in the United States. They are extremely stable chemically and have a low reactivity. Each of the PCB molecules can contain one to ten chlorine atoms attached to the biphenyl molecule. The biphenyl consists of two hexagonal "phenyl" rings bonded with a carbon-bond. The phenyl rings are able to rotate about this bond and form planar (in the same plane) to nonplanar (rings at a 90° angle to each other) molecules. From this molecular structure, there are 209 possible compounds, or congeners, that comprise the PCB class of compounds. Each of the congeners is given a unique CAS Number for identification of the compound.



**Polychlorinated Biphenyl Molecule (1 to 10 chlorine Atoms)**

PCBs can be classified as to the degree of chlorination, or the number of chlorines added to the molecule. All PCBs belong to one of ten homolog groups; compounds within the same homolog group are referred to as isomers.

Homolog Group	# of Chlorines	# of Congeners	Congener Numbers
Monochlorobiphenyl	1	3	1-3
Dichlorobiphenyl	2	12	4-15
Trichlorobiphenyl	3	24	16-39
Tetrachlorobiphenyl	4	42	40-81
Pentachlorobiphenyl	5	52	82-127
Hexachlorobiphenyl	6	42	128-169
Heptachlorobiphenyl	7	24	170-193
Octachlorobiphenyl	8	12	194-205
Nonachlorobiphenyl	9	3	206-208
Decachlorobiphenyl	10	1	209

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Structurally, the chlorines attached at locations 2, 2', 6, 6' are in the ortho positions, at locations 3, 3', 5, 5' are in the meta positions and at locations 4 and 4' are in the para positions. More than one chlorine atom attached at ortho positions forces the molecule into a non-planar configuration; these molecules are referred to as non-planar congeners. The mono-ortho substituted and non-ortho substituted congeners assume a planar configuration and are referred to as planar congeners. The planarity (angle between the rings) is determined to a large degree by substitution of chlorine for hydrogen atoms in the ortho positions.

PCBs were produced in the United States between about 1929 and 1977 as complex mixtures of individual congeners known as "Aroclors."<sup>1</sup> Each Aroclor mixture is identified by a four-digit numbering code, the last two digits of which generally refer to the average percent of chlorine by weight. "Aroclor 1248," for example, contains 48% chlorine by weight. While Aroclor 1248 is 48 percent chlorinated by average (approximately 5 chlorine atoms), it has congeners that have less than 5 chlorine atoms and greater than 5 chlorine atoms. In comparison, Aroclor 1260 is 60 percent chlorinated, and that comprises congeners that have more chlorine atoms attached to the molecule. The weight percent of individual congeners in mixtures of Aroclor 1242, 1248, 1254 and 1260 are shown in Figure 1. This figure illustrates the relative percentage of each congener present in the parent Aroclor mixtures. Aroclor 1260 is comprised of the more highly chlorinated congeners while Aroclor 1242 is a mixture of the lesser chlorinated congeners. As evident from the figure, Aroclors are very complex mixtures of the 209 possible PBC congeners.

## 2.2 CHEMICAL PROPERTIES AND DEGRADATION OF PCBs

The individual congeners that make up these Aroclors all have differing properties, including, for example, solubility, adsorption, volatilization rates or degradation rates. PCBs have moderate water solubility, relatively high partitioning to organic matter (Octanol Water Partition Coefficient- $K_{OW}$ 's), and are moderately volatile. Adsorption favors long retention time and slow migration. The differing chemical properties of the congeners result in differences in their migration once released to the environment. The congeners that all have four chlorine atoms attached to them would have similar properties and thus behave similarly as a group, although there might be subtle differences in the chemical properties. But when you go from monochlorinated PCB all the way through the decachlorinated (or the most highly chlorinated congener), they would have greatly differing properties. The differing compound properties affect not only their migration through the environment but also certain analytical methods used to evaluate PCB content of environmental samples. A summary of the different Aroclor properties is shown in Table 1, reproduced from the Agency for Toxic Substance and Disease Registry (ATSDR).<sup>2</sup> Properties of individual congeners have been reported in the literature and a summary of selected congeners (PCB 77, 138, 153, 169, 180) is shown in Table 2<sup>3</sup>.

<sup>1</sup> ATSDR ToxProfile, Section 5, <http://www.atsdr.cdc.gov/toxprofiles/tp17-c5.html>.

<sup>2</sup> <http://www.atsdr.cdc.gov/toxprofiles/tp17-c4.html>, Table 4-3.

<sup>3</sup> <http://www.atsdr.cdc.gov/toxprofiles/tp17-c4.html>, Table 4-7.

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The important point to realize from Figure 1 and Tables 1 and 2 is that the overall chlorination level increases as we go from 1242 to 1260 and the associated individual congener properties change with chlorination. The higher level congeners are generally more stable in the environment; they are less volatile and more resistant to degradation. The differences in compound properties will affect individual congener persistence in the environment as well as its rate of migration through environmental media. As PCB congeners move through the environment, the absolute and relative concentrations of individual congeners change over time due to differences in the chemical properties as well as differences in the rate of degradation and bioaccumulation by living organisms.

## 2.3 ANALYTICAL METHODS FOR PCB ANALYSIS OF SAMPLES

Several analytical methods are available for quantitation of total PCBs in environmental samples. Those methods, listed in order from general, low accuracy to higher accuracy include:

- Method 8082: Aroclor-based method using capillary column with GC/ECD,
- Method 680: Homolog-based quantification methods using GC/MS, and
- Method 1668: Congener-specific analysis method using high resolution GC/MS.

In general, GC/ECD methods which are based on pattern recognition of parent Aroclor mixtures (Figure 1), have higher detection limits than other specific methods and have limited application for environmental samples where weathering and degradation have taken place. PCB concentrations derived from Aroclor methods may underestimate total PCBs. The analysis of PCBs by the Homolog Method provides more complete determination of total PCBs in environmental samples, although it is a low resolution analysis and generally has higher detection limits than high resolution methods. In one study, results of PCBs in six fish samples as determined by Aroclor Analysis and Homolog Analysis (Greene, 1991) were compared. On the average, the homolog method gave PCB estimates that were 230 percent higher than the results from the Aroclor method. The high resolution method based on congener analysis using GC/MS is the most accurate method for the determination to total PCB content as well as for delineation of specific congeners.

### 2.3.1 Aroclor Testing of PCBs by GC/ECD, Method 8082<sup>4</sup>.

Method 8082 is used to determine the concentrations of polychlorinated biphenyls (PCBs) as Aroclors or as individual PCB congeners in extracts from solid and aqueous matrices. Open tubular, capillary columns are employed with electron capture detectors (ECD) or electrolytic conductivity detectors (ELCD). The target analytes are: Aroclor 1016, Aroclor 1221, Aroclor 1232, Aroclor 1242, Aroclor 1248, Aroclor 1254, Aroclor 1260, and congeners 1, 5, 18, 31, 44,

<sup>4</sup> EPA 1996, Method 8082 Polychlorinated Biphenyls (PCBs) By Gas Chromatography, Revision 0. SW-846. <http://www.epa.gov/epaoswer/hazwaste/test/pdfs/8082.pdf>

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52, 66, 87, 101, 110, 138, 141, 151, 153, 170, 180, 183, 187, and 206. Using this approved analytical method, analytical chemists base their determination of PCBs in samples as specific Aroclors, i.e. Aroclor 1242 or Aroclor 1260, on comparisons of chromatograms of pure product to chromatograms of the sample. They recognize that absolute ratios of congeners of environmental samples may differ from pure product. The analysis is used to quantify how much of the compound is present as each one of these Aroclors, if they are identified. In the analytical method, the analyst will look at only several of the characteristic peaks found in the parent Aroclors. For example, they may pick three of those peaks, they may pick four, they may pick five of those peaks, to determine whether or not Aroclor 1260 is present. If the "pattern" for Aroclor 1248 is present, the concentration is quantitated by comparison to standard solutions of a known concentration.

One of the main problems in the analysis of environmental samples using Aroclor Methods is the underreporting of the total PCB content of many samples. If the analytical chemist does not see a "pattern" of the characteristic congeners for a particular Aroclor (one of the difficulties in matching the environmental occurrence of the individual congeners to one of the parent Aroclors), the analysis becomes more difficult and the presence of a particular Aroclor is not reported. If the analyst does not observe the congeners that they are interested in with respect to a specific Aroclor, if one or two of those are absent, if three are absent, or if they are present in greatly differing ratios between each other, the analyst may conclude that there is a "non-detect of one of the specific Aroclors". The Aroclors may be reported as "non-detect" even though some of the congeners are present in the sample. This leads to the common underreporting of PCB content of environmental samples.<sup>5 6</sup>

In addition, Aroclor analysis does not take into account the varying toxicity of congeners. The number and position of the chlorine atoms on the biphenyl rings also influence how biological organisms incorporate and are affected by exposure to PCBs. PCBs with hydrogen atoms on two adjacent carbon atoms are more readily metabolized than those with hydrogen atoms adjacent to the chlorine atoms (Bernhard and Petrone, 2001<sup>7</sup>). Analysis for toxic congeners can provide stronger relationships to toxicity than non-specific methods. The more accurate, but more expensive and less frequently used, means of measuring PCBs in the environment is congener testing.

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<sup>5</sup> Greene, R. W. 1991. Chemical Contaminants in Finfish from the Chesapeake and Delaware Canal and Implications to Human Health Risk. Delaware Department of Natural Resources and Environmental Control, Dover, DE.

<sup>6</sup> Colby, B. and Anderson, T, 2000. Bicoastal Biphenyls: PCB Homologue Group Analysis and Toxicology in Maine and California. The Standard, v.5, No. 1, Cambridge Isotope Laboratories, June.

<sup>7</sup> Bernhard, T. and Petrone, S., 2001. Analysis of PCB Congeners vs. Aroclors in Ecological Risk Assessment, <http://web.ead.anl.gov/ecorisk/issue/pdf/PCB%20IssuePaperNavy.pdf>.

### 2.3.2 PCB Homolog Analysis by EPA Method 680<sup>8</sup>:

Method 680 uses low resolution GC/MS to identify and quantify PCB congeners grouped by homolog (mono, di, tri - chlorinated for example). The congeners are confirmed by the ratios of the responses of ions within the compounds. An expected ratio for the ions and an acceptable range is specified in the method (EPA, 2002). While this method provides a more complete accounting of the groups of PCB congeners present in a sample than the Aroclor method, the low resolution method has higher detection limits than high resolution methods used for individual congener analysis. Depending on the matrix of the sample, dilution or interferences along with poor recovery of spiked compounds may lead to underestimation of Total PCB content of a sample.

### 2.3.3 Individual PCB Congener Analysis by High Resolution Gas Chromatography/Mass Spectrometry, EPA Method 1668<sup>9</sup>

The 209 PCB congeners can be determined by HR/GC, 137 of which can be resolved as individual congeners. The method also allows for the estimation of homolog totals by level of chlorination by identification of the earliest and latest eluted congener from each level. The 12 congeners of the WHO list and the level of chlorination congeners are determined by the use of labeled isotopes and the remaining congeners are determined by internal standards (EPA, 1999).

This method is a more specific analytical method and provides the best indication of the Total PCB content in environmental samples.

### 2.3.4 Discussion of Total PCB Content of AK Steel Samples by the Three Analytical Methods.

In the recent sampling at the site, sixteen samples were analyzed by each of the three analytical methods discussed above. The results indicate that PCBs determined by the Congener Method provided the most complete accounting of the Total PCB content. Both the Aroclor Method and the Homolog Method underestimated the PCB content of the samples as shown in Figures 2 and 3.<sup>10</sup> While it is generally accepted that the Homolog Analysis should be more precise than the

<sup>8</sup> EPA, 2002. Standard Operating Procedure (SOP) GEHR680, General Electric (GE) Hudson River Design Support Sediment Sampling And Analysis Program, Standard Operating Procedure For The Determination Of PCBs In Sediment By Gas Chromatography/Mass Spectrometry By EPA Method 680, Revision No.: 1, [http://www.epa.gov/hudson/Exhibit\\_B\\_Final\\_7-18-02.pdf](http://www.epa.gov/hudson/Exhibit_B_Final_7-18-02.pdf)

<sup>9</sup> EPA, 1999. Method 1668, Revision A: Chlorinated Biphenyl Congeners in Water, Soil Sediment and Tissue by HRGC/HRMS. Office of Water. EPA 821-R-00-002.

<sup>10</sup> The Aroclor analysis for Sample S43 was slightly above the total PCB by the Congener method.

Aroclor analysis by GC/ECD has been shown to underestimate total PCB concentrations in environmental samples because it is based on pattern recognition, and environmental samples often do not contain pure forms of PCB Aroclors. Examples of data from the AK Steel site illustrate how such underestimation can take place (Figures 4, 5, and 6).

11 Analysis for PCB homologs were performed by STL. Case narratives, results and raw data are included in the data package were reviewed for this report. Homologue analysis by low resolution GC/MS is reported to be more accurate than higher resolution methods because the method is impacted by less interference. The trade-off is that it also has higher detection limits. In the AK Steel data, detection limits and raised detection limits (due to dilution) contributed to the underestimation of PCBs by this method. Low surrogate recovery indicates that the results may be biased low; in addition, there are few detections of mono, hepta, octa, nona and deca CBs which are shown to be present by the congener results. For example, in S01, which was dilute by a factor of 5, monochlorinated biphenyl is less than 23 ug/kg; however, congener 1, the monoCB is present in the congener analysis at 35 ug/kg. Hepta - deca CBs were not detected at 70 - 120 ug/kg, however there are numerous detections of congeners numbered greater than 170, the lowest numbered heptaCB.

Method 680 uses low resolution GC/MS to identify and quantify PCB congeners grouped by homolog (mono, di, tri – chlorinated for example). The congeners are confirmed by the ratios of the responses of ions within the compounds. An expected ratio for the ions and an acceptable range is specified in the method (EPA, 2002)<sup>11</sup>. The QC program included surrogates, internal standards, method blanks, spike/spike duplicated, and laboratory control samples.

- Due to interference from the internal standard in Sample S43, dilution and the resulting dilution at 1:20, the surrogate was not recovered.
- Matrix interference required the dilution of six samples at 1:5.
- In 12 of the 19 samples, the internal standard phenanthrene-d10 was recovered outside of the test ratio. The compound is not used for quantitation so data should not be impacted.
- Sample S23 was diluted and rerun, both results are shown. (The initial data are designated with E flags).

In addition to those mentioned in the narrative, two other QC issues were noted in the package:

- The surrogate recovery of 31-66% is low, although it is within the QC range listed in the data package (30-130%). Other SOPs for this method (EPA 2002) show more restrictive QC limits of 60-140 % for surrogate recovery, indicating that this is a liberal limit and these data are at the low end.
- In the MS/MSD 14 of the 18 target compounds were outside of the QC limits for spike recovery (page 55). The recovery for mono- and di-chloro homologs were 30-34%, just within the acceptable limit of 30-130%. In the tri- to deca-chlorinated homologs, the recoveries were 5-20%. The QC limits are 30-130% or 40-140% for these groups.

Corrective actions required for MS/MSD that are out of compliance (EPA 2002) should include checking the system function and the lab control sample results. If the system is functioning properly and the LCS is within limits (which is the case for this data package) then matrix effects are assumed to be the cause of the low recoveries (EPA 2002, page 15).

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In samples S43 and S12, the only Aroclor detected was Aroclor 1248. As shown in Figure 4, the patterns are not identical to the standard for Aroclor 1248. Congener data for both samples show that congeners 1 through 20 are present at higher ratios than expected from the standard. In addition, there are also detections of congeners 170 – 206 that are not present in pure 1248. The dominant peaks in Aroclor 1248 are 44, 49, 52, 66 and 70. Because these peaks are not dominant in the samples and congeners are present in different ratios, the quantitation does not reflect those congeners that are outside of these ratios, resulting in an underestimation. Similar issues stand out in the comparison of samples S07 and S09 to the Aroclor 1242 standard. Significant peaks are present in the low congener numbers, less than 20, which are outside of the peak pattern for 1242, and low-level concentrations were detected for congeners greater than 170 that are not present in the standard.

Congener patterns in sample S30 indicate the presence of more highly chlorinated compounds that in most of the other samples, as is reflected by the detection of Aroclor 1254; however, as discussed above, this weathered or possibly multi-component sample shows significant differences from the standard pattern resulting in underestimation of the total PCB concentration. Sample S30 contains congeners at both the high and low ends of the spectrum (1-30 and 185-209) that are not present in the standard. The ratios of other components, such as 45, 52, 90, and 110, to the dominant congener, 118, are higher than those in the standard.

These results illustrate that the PCB analysis by the Congener Method provides the most accurate determination of PCB content of the samples. This method also yields the best detection limits, as well as the most specificity with respect to individual compounds than either of the other methods.

*Naeb conclusion*

## Figures

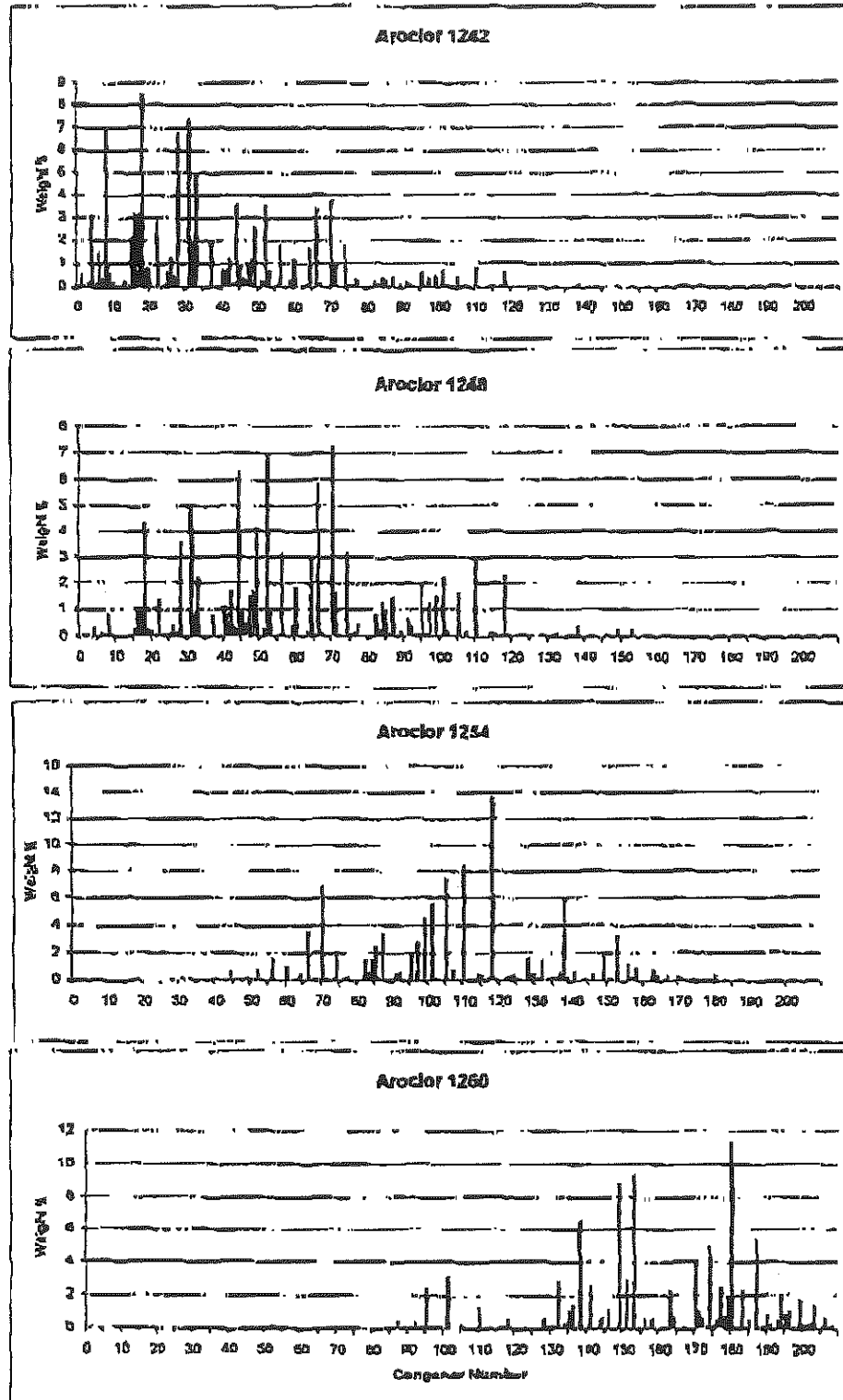


Figure 1  
Aroclor Composition (from Frame, et al, 1996)

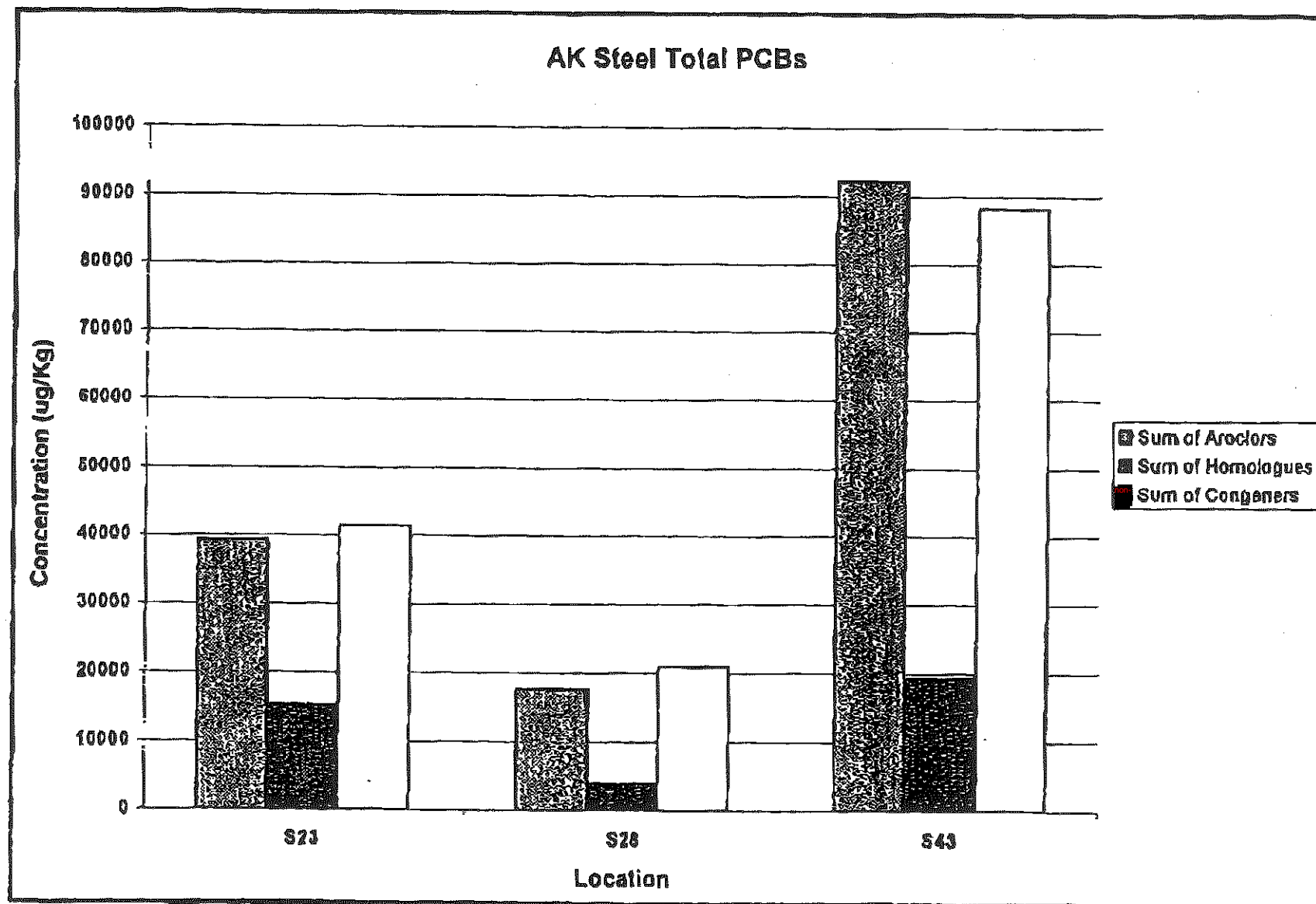


Figure 2. Comparison of the Three Analytical Methods for PCB Analysis of AK Steel Samples S23, S28 and S43.

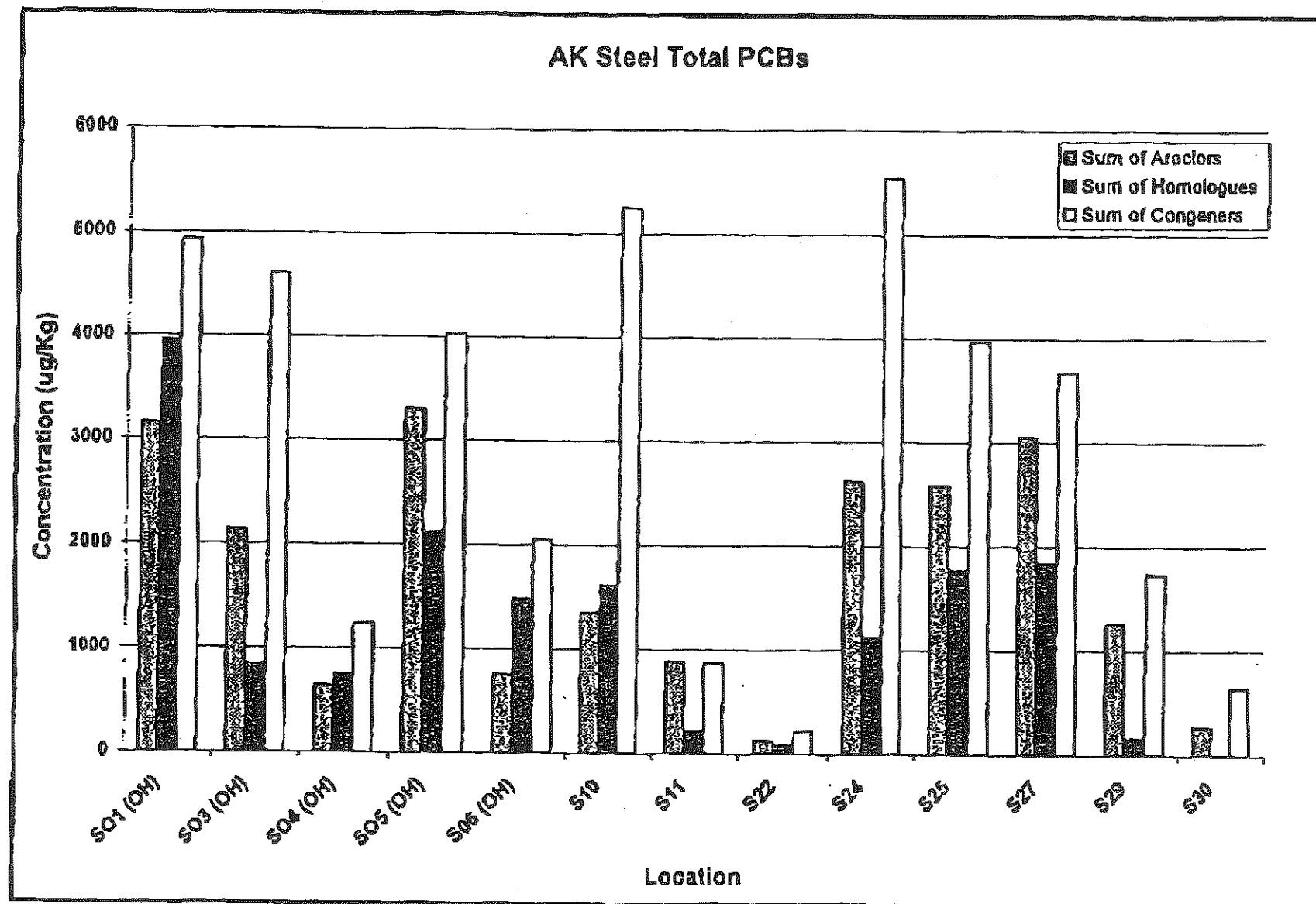
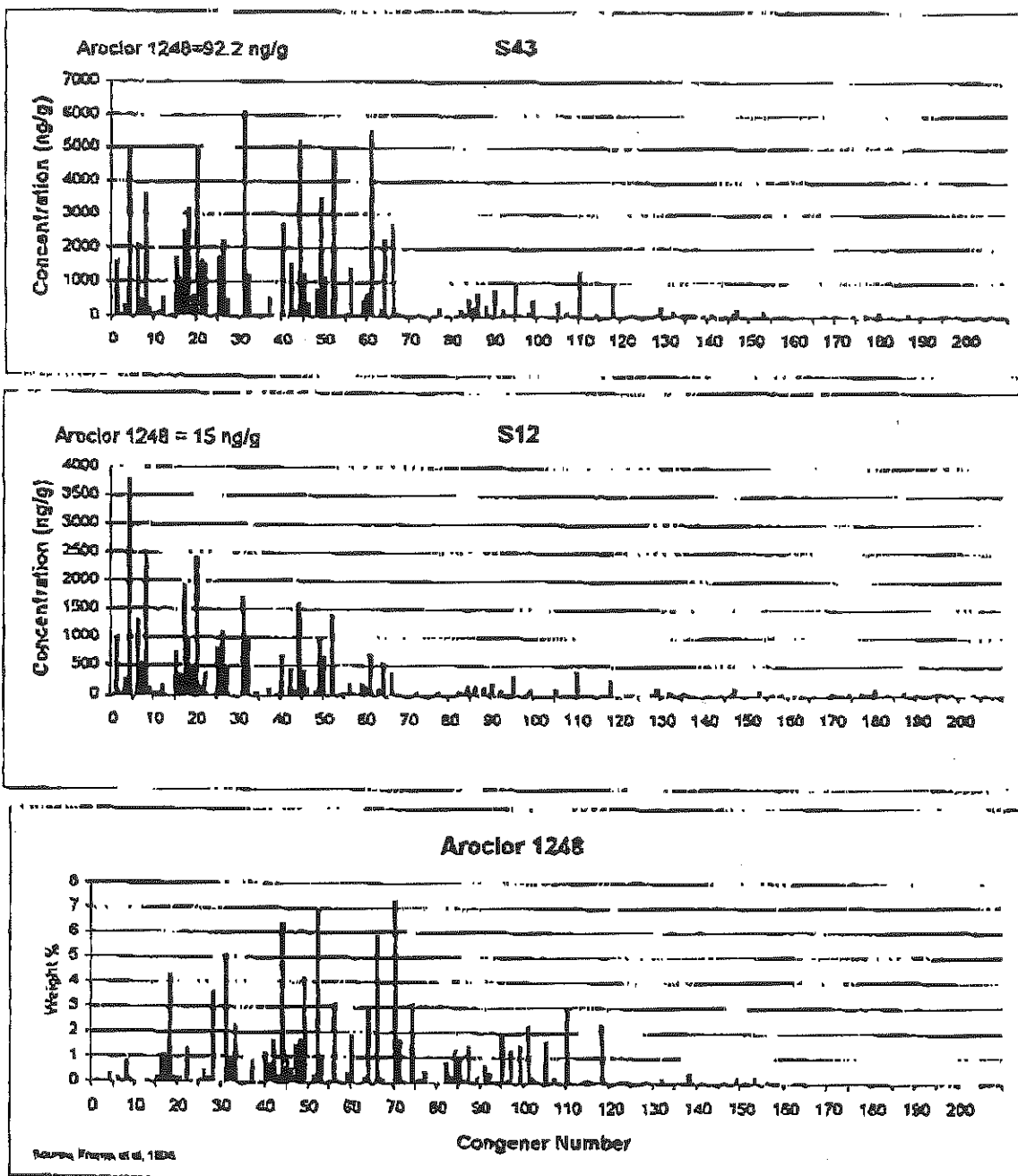


Figure 3. Comparison of the Three Analytical Methods for PCB Analysis of AK Steel Samples S01, S03, S04, S05, S06, S10, S11, S22, S24, S25, S27, S29 and S30.



**Figure 4**  
**Congener Patterns, S12 and S43**

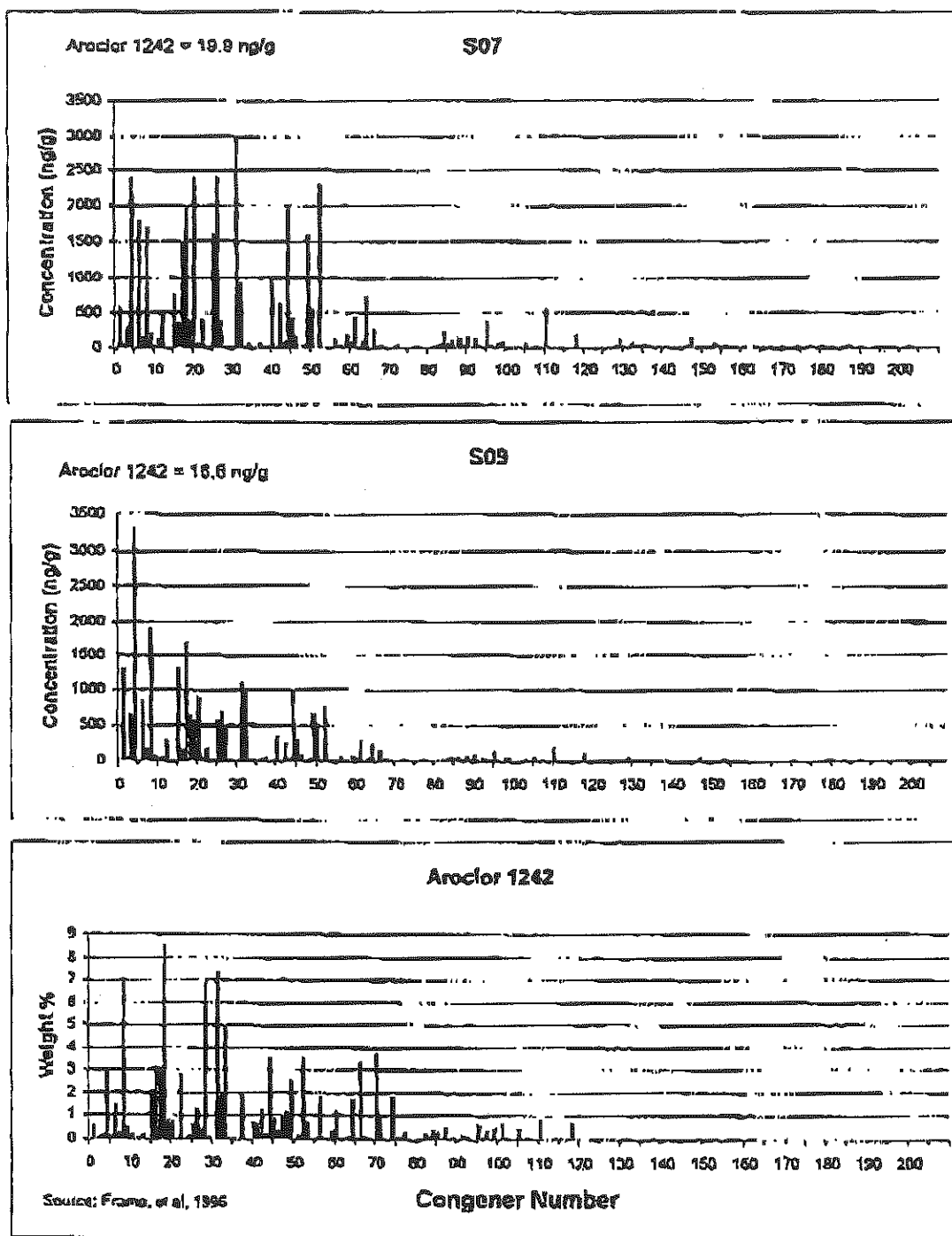


Figure 5  
Congener Patterns S07 and S09

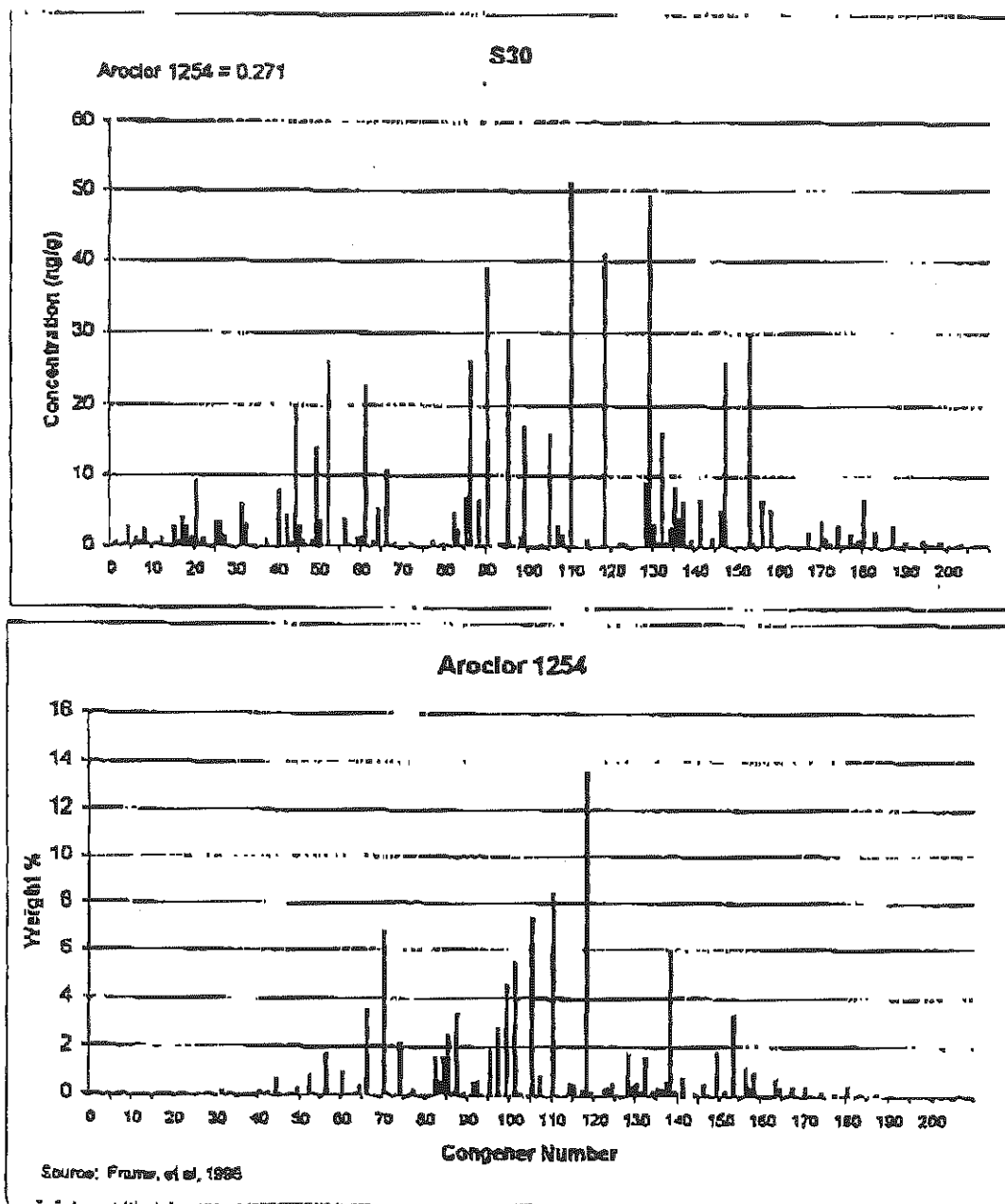


Figure 6  
Congener Patterns S30

## Tables

PCBs

## 4. CHEMICAL AND PHYSICAL INFORMATION

453

**Table 1**  
**Physical and Chemical Properties of Some Aroclors<sup>a</sup>**

Property	Aroclor 1016	Aroclor 1221	Aroclor 1232	Aroclor 1242
Molecular weight <sup>b</sup>	257.9 <sup>c</sup>	200.7 <sup>c</sup>	232.2 <sup>c</sup>	266.5 <sup>c</sup>
Color	Clear	Clear	Clear	Clear
Physical state	Oil	Oil	Oil	Oil
Melting point, °C	No data	1 <sup>d</sup>	No data	No data
Boiling point, °C	325–356	275–320	290–325	325–366
Density, g/cm <sup>3</sup> at 25 °C	1.37	1.18	1.26	1.38
Odor	No data	No data	No data	Mild hydrocarbon <sup>e</sup>
Odor threshold:				
Water	No data	No data	No data	No data
Air	No data	No data	No data	No data
Solubility:				
Water, mg/L	0.42 (25 °C) <sup>e</sup>	0.59 (24 °C) <sup>f</sup>	0.45 (25 °C)	0.24 <sup>g</sup> ; 0.34 (25 °C) <sup>g</sup> 0.10 (24 °C) <sup>f</sup>
Organic solvent(s)	Very soluble <sup>g</sup>	Very soluble <sup>g</sup>	Very soluble <sup>g</sup>	Very soluble <sup>g</sup>
Partition coefficients:				
Log K <sub>ow</sub> <sup>h</sup>	5.6	4.7	5.1	5.6
Log K <sub>oc</sub>	No data	No data	No data	No data
Vapor pressure, mm Hg at 25 °C	4x10 <sup>-4c</sup>	6.7x10 <sup>-3c</sup>	4.06x10 <sup>-3c</sup>	4.06x10 <sup>-4c</sup>
Henry's law constant, atm-m <sup>3</sup> /mol at 25 °C	2.9x10 <sup>-4</sup>	3.5x10 <sup>-4</sup>	No data	5.2x10 <sup>-4</sup>
Autoignition temperature	No data	No data	No data	No data
Flashpoint, °C (Cleveland open cup)	170	141–150	152–154	176–180
Flammability limits, °C	None to boiling point	176	328	None to boiling point
Conversion factors				
Air (25 °C) <sup>j</sup>	1 mg/m <sup>3</sup> =0.095 ppm	1 mg/m <sup>3</sup> =0.12 ppm	1 mg/m <sup>3</sup> =0.105 ppm	1 mg/m <sup>3</sup> =0.092 ppm
Explosive limits	No data	No data	No data	No data

Table 1 (continued, page 2/3)  
Physical and Chemical Properties of Some Aroclors<sup>a</sup> (continued)

Property	Aroclor 1254	Aroclor 1260	Aroclor 1262	Aroclor 1268
Molecular weight <sup>b</sup>	328 <sup>c</sup>	357.7 <sup>c</sup>	389	453
Color	Light yellow	Light yellow	No data	Clear <sup>t</sup>
Physical state	Viscous liquid	Sticky resin	No data	Viscous liquid <sup>t</sup>
Melting point	No data	No data	No data	No data
Boiling point, °C	365–390	385–420	390–425	435–450
Density, g/cm <sup>3</sup> at 25 °C	1.54	1.62	1.64	1.81
Odor	Mild hydrocarbon <sup>d</sup>	No data	No data	No data
Odor threshold:				
Water	No data	No data	No data	No data
Air	No data	No data	No data	No data
Solubility:				
Water, mg/L	0.012 <sup>e</sup> ; 0.057 (24 °C)	0.0027 <sup>e</sup> ; 0.08 (24 °C) <sup>f</sup>	0.052 (24 °C) <sup>f</sup>	0.300 (24 °C) <sup>f</sup>
Organic solvent(s)	Very soluble <sup>g</sup>	Very soluble <sup>g</sup>	No data	Soluble
Partition coefficients:				
Log K <sub>ow</sub>	6.5	6.8	No data	No data
Log K <sub>oc</sub>	No data	No data	No data	No data
Vapor pressure, mm Hg at 25 °C	7.71x10 <sup>-4</sup> <sup>c</sup>	4.05x10 <sup>-3</sup> <sup>c</sup>	No data	No data
Henry's law constant, atm-m <sup>3</sup> /mol at 25 °C	2.0x10 <sup>-3</sup>	4.6x10 <sup>-3</sup>	No data	No data
Autoignition temperature	No data	No data	No data	No data
Flashpoint °C (Cleveland open cup)	No data	No data	195° C	195° C

PCBs

4. CHEMICAL AND PHYSICAL INFORMATION

454

PCRs

4. CHEMICAL AND PHYSICAL INFORMATION

455

Table 1 (continued, page 3/3)

Physical and Chemical Properties of Some Aroclors<sup>a</sup> (continued)

Property	Aroclor 1254	Aroclor 1260	Aroclor 1262	Aroclor 1268
Flammability limits, °C	None to boiling point	None to boiling point	None to boiling point	None to boiling point
Conversion factors, Air (25 °C) <sup>b</sup>	1 mg/m <sup>3</sup> =0.075 ppm	1 mg/m <sup>3</sup> =0.065 ppm	1 mg/m <sup>3</sup> =0.081 ppm	1 mg/m <sup>3</sup> =0.052 ppm
Explosive limits	No data	No data	No data	No data

<sup>a</sup>All information obtained from Monsanto Chemical Company 1985 and Hutzinger et al. 1974 unless otherwise noted.

<sup>b</sup>Average weight from Table 3-3.

<sup>c</sup>EPA 1979h; data on temperature not available.

<sup>d</sup>NIOSH 1997

<sup>e</sup>Paris et al. 1978

<sup>f</sup>Mollified 1979

<sup>g</sup>EPA 1985b

<sup>h</sup>These log K<sub>ow</sub> values represent an average value for the major components of the individual Aroclor. Experimental values for the individual components were obtained from Hansch and Leo 1985.

<sup>i</sup>These Henry's law constants were estimated by dividing the vapor pressure by the water solubility. The first water solubility given in this table was used for the calculation. The resulting estimated Henry's law constant is only an average for the entire mixture; the individual chlorobiphenyl isomers vary significantly from the average. Burkhard et al. (1985) estimated the following Henry's law constants (atm-m<sup>3</sup>/mol) for various Aroclors at 25 °C: 1221 (2.28x10<sup>-4</sup>), 1242 (3.43x10<sup>-4</sup>), 1248 (4.4x10<sup>-4</sup>), 1254 (2.83x10<sup>-4</sup>), and 1260 (4.15x10<sup>-4</sup>).

<sup>j</sup>These air conversion factors were calculated by using the average molecular weight and ideal gas law.

<sup>k</sup>Chemical Health and Safety Data; National Toxicology Program (<http://ntp-server.niehs.nih.gov>)

Table 2

## Physical and Chemical Properties of Several Congeners of Polychlorinated Biphenyls

Property	PCB 77	PCB 138	PCB 153	PCB 169	PCB 180
Molecular weight	291.98 <sup>a</sup>	360.8 <sup>b</sup>	360.88 <sup>b</sup>	360.86 <sup>a</sup>	395.32 <sup>b</sup>
Molecular formula	C <sub>12</sub> H <sub>6</sub> Cl <sub>6</sub> <sup>b</sup>	C <sub>12</sub> H <sub>4</sub> Cl <sub>8</sub> <sup>c</sup>	C <sub>12</sub> H <sub>4</sub> Cl <sub>6</sub> <sup>b</sup>	C <sub>12</sub> H <sub>4</sub> Cl <sub>6</sub> <sup>b</sup>	C <sub>12</sub> H <sub>2</sub> Cl <sub>8</sub> <sup>b</sup>
Melting point °C	173 <sup>d</sup>	78.5–80 <sup>c</sup>	103–104 <sup>e</sup>	201–202 <sup>c</sup>	109–110 <sup>b</sup>
Boiling point °C	360 (calc.) <sup>a</sup>	400 (calc.) <sup>b</sup>	No data	No data	240–280 (20 mmHg) <sup>b</sup>
Density g/cm <sup>3</sup> at 25 °C	1.2024 (20 °C) <sup>a</sup>	No data	No data	No data	No data
Odor	No data	No data	No data	No data	No data
Solubility:					
Water mg/L	0.175 ppm <sup>c</sup> ; 0.00055 <sup>a</sup>	0.0159–0.0159 (calc.) <sup>b</sup>	0.00091 ppm <sup>c</sup> ; 0.00086 <sup>a</sup>	0.000036–0.01230 (calc.) <sup>b</sup>	0.00031–0.00656 (calc.) <sup>b</sup> ; 0.00023 <sup>a</sup>
Organic solvents	—	—	—	—	—
Partition coefficients:					
Log K <sub>ow</sub>	6.04–6.63 <sup>b</sup>	6.50–7.44 (calc.) <sup>b</sup>	8.35 <sup>a</sup> ; 6.72 <sup>b</sup>	7.408 <sup>b</sup>	6.70–7.21 (calc.) <sup>b</sup>
Log K <sub>oc</sub>	4.41–5.76 <sup>b</sup>	5.21–7.3 <sup>b</sup>	4.75–7.68 <sup>b</sup>	6.60 <sup>b</sup>	5.78–6.9 <sup>b</sup>
Vapor pressure mm Hg at 25 °C	4.4x10 <sup>-7</sup> <sup>a</sup>	4.0x10 <sup>-8</sup> <sup>c</sup>	3.80x10 <sup>-7</sup> <sup>c</sup> ; 9.0x10 <sup>-7</sup> <sup>c</sup>	4.02x10 <sup>-7</sup> <sup>a</sup>	—
Henry's law constant atm-m <sup>3</sup> /mol at 25 °C	0.43x10 <sup>-4</sup> <sup>c</sup> ; 0.94x10 <sup>-4</sup> <sup>d</sup> ; 0.83x10 <sup>-4</sup> <sup>a</sup>	1.07x10 <sup>-4</sup> <sup>c</sup> ; 0.21x10 <sup>-4</sup> <sup>b</sup>	2.78 (10 <sup>4</sup> ) <sup>a</sup> ; 1.32 (10 <sup>4</sup> ) <sup>c</sup> ; 1.31 (10 <sup>4</sup> ) <sup>a</sup>	0.15x10 <sup>-4</sup> <sup>b</sup> ; 0.59x10 <sup>-4</sup> <sup>b</sup>	1.07x10 <sup>-4</sup> <sup>a</sup>
Explosive limits	No data	No data	No data	No data	No data

<sup>a</sup>HSDB 2000<sup>b</sup>Yalkowsky et al. 1983<sup>c</sup>Hutsinger et al. 1974<sup>d</sup>Mackay et al. 1992<sup>e</sup>Dunnivant et al. 1992

Erikson 1986

<sup>f</sup>Hansch and Leo 1995<sup>g</sup>Bidelman 1984<sup>h</sup>Murray and Andren 1991

PCBs

4. CHEMICAL AND PHYSICAL INFORMATION

486

## **APPENDIX A**

### **RESUME**

**Allen J. Medine, Ph.D., P.E.**

**Environmental Engineering/ Environmental Chemistry**

#### **EDUCATION**

Utah State University, Ph.D., Environmental Engineering, w/Chemistry minor, 1980.

University of California, Berkeley, M.S., Civil (Sanitary) Engineering, 1973.

University of Illinois, Urbana, B.S., Civil Engr, James Scholar w/High Honors, 1972.

#### **PROFESSIONAL HISTORY**

Environmental Engineering Consultant, 1992-2000, 2003-present

HydroQual, Inc. Vice-President, Principal Engineer and Director, Colorado Office, 2000 to 2003

Walsh and Associates, Vice President, 1990-1992

Jacobs Engineering, Senior Environmental Engineer, 1988-1990

Enseco Rocky Mountain Analytical Laboratory, Technical Director, 1987-1988

Environmental Engineering Consultant, 1985-1987

University Faculty, 1978-1985 (see details, page 3)

Greeley and Hansen, Design Engineer, 1973-1975

#### **REPRESENTATIVE EXPERIENCE:**

Dr. Medine has over 29 years of professional experience in civil/environmental engineering and environmental chemistry, including seven years of teaching and research in Civil and Environmental Engineering. He has worked on a wide variety of civil/environmental engineering and environmental science projects, and provided a wide range of technical support at over two dozen Superfund sites, including litigation support on 15 Superfund projects and expert testimony in federal court.

He was a project manager and senior environmental engineer for the evaluation of technologies, development of treatability studies, critique of experimental results and selection of appropriate technology for contaminated water, sediments, soils, sludges, and wastes at numerous NRDA and CERCLA waste sites, including Weldon Spring Site (DOE, MO), Sheridan Disposal Services (TX), California Gulch (CO), Idarado Mining & Milling (CO), Clear Creek (CO), Blackbird Mine (ID), Eagle Mine (CO), Elmendorf AFB (AK), Champion International (MT), Kennecott Mine/Smelter (UT), Chemplex (IA) and 12 others. His senior level technology assessments during performance of RI/FSs and RD/RAs include a broad range of technologies and contaminants, including mixed waste, radioactive (U, Th, Ra, Rn), metals, pesticides, petroleum wastes, chlorinated organics, PAHs, fuels and others. Dr. Medine has designed bench-scale and pilot-scale treatability studies for bioremediation (in-situ/ex-situ), physical / chemical treatment, solidification and sorption treatment for mining waste, mixed-waste and organics.

He was the project manager and senior environmental engineer at over two dozens SUPERFUND sites involving a full range of field operations designed to gather information for remedial technology application toward site cleanup. Field operation expertise includes site assessments, risk assessment, development of monitoring programs, contamination delineation, bioassessments, health & safety plans, sampling and analysis plans as well as data validation, reduction and interpretation. He has used numerical contaminant transport modeling in conjunction with GIS systems to integrate large quantities of environmental data to evaluate waste treatment location / volumes, transport pathways, soil erosion, sediment and floodplain dynamics and historical, natural contaminant loadings and total maximum daily loadings to meet water quality standards.

Dr. Medine has been committed to technology transfer and research in surface water quality management for 29 years, including the development, testing and application of modeling to determine maximum contaminant loadings needed to attain water quality standards. He has taught both technical workshops and university courses on water quality management, modeling for toxics & conventional pollutants, environmental and analytical chemistry, permitting and methods for meeting standards using innovative treatment technologies and analysis of total maximum daily loadings. His expertise includes hazardous waste management, watershed management and restoration of damaged ecosystems, behavior of toxic substances in the environment, hydrologic and sediment transport modeling, water quality and contaminant transport modeling, river basin hydrology and geomorphology. He has worked extensively with CWA, CERCLA, RCRA, NRDA regulations and procedures.

He has published over two dozen technical papers and prepared in excess of 36 technical reports on a variety of environmental engineering topics. He has also presented numerous seminars, invited papers and technical papers at national and international conferences and symposia and chaired sessions at various conferences. He has been a reviewer of technical papers for Water Research (IAWQ), ASTM, USEPA, National Research Council, ASCE and various publishers, and, a reviewer of research proposals submitted to the U.S. Environmental Protection Agency and National Science Foundation.

## **SPECIFIC EXPERIENCE**

### **Client: U.S. EPA.**

Dr. Medine was a project manager and senior environmental engineer for technical oversight of PRP activities under EPA's TES IV and ARCS program. In this capacity, he provided coordination of technical review of all RI/FS, RD/RA documents at 9 major Superfund sites including mining sites and organic chemical sites (technical review included review of feasibility studies, RD planning documents, site characterization plans, QA/QC plans, fate and transport studies, modeling, remedial designs, and technology demonstration plans).

### **Client: City of Thornton**

HydroQual (initially through Medine Environmental Engineering) supported the City of Thornton for expert technical services on Regulation 31, Regulation 38, nitrate TMDL assessment for the South Platte River, the Englewood Water Rights Case, the Denver Case and other issues on an as needed basis. The work involved data analysis, strategy meetings, document review, preparing testimony for the Water Quality Control Commission and offering testimony before the Commission.

### **Client: U.S. EPA, National Risk Management Research Lab**

He has been a long-time consultant to the EPA's Risk Reduction Engineering Laboratory (RREL), presently the NRMRL in Cincinnati, OH and has recently provided technical support to EPA VIII on the Summitville Mine site and the Clear Creek/Central City Superfund Site. This technical support has included the development of the Metal Exposure and Transformation Assessment Model (META4), metal speciation submodel to be used with the WASP4 modeling system. The model was developed to predict water quality improvement resulting from numerous remedial action scenarios, and to provide a more realistic tool for the determination of Total Maximum Daily Loadings to meet water quality standards. A recent project involved the application of this metal speciation and sediment transport model at the Clear Creek/Central City Superfund Site which included an assessment of contaminant source areas, total daily maximum watershed and source area loadings, transformation processes, pathways and receptor exposure analysis. Modeling has been used to determine maximum daily loadings that would permit an attainment of water quality standards for cadmium, manganese, lead, zinc and copper in both the mainstem and North Fork Clear Creek.

**Client: U.S. EPA, Center for Exposure Assessment Modeling and the Environmental Research Laboratory (ERL) in Athens, GA**

Dr. Medine has provided technical support on chemical modeling of environmental systems, testing of new EPA models, peer review of modeling applications, and workshops on MINTEQA2.

**Client: Enseco-Rocky Mountain Analytical Lab (presently Quanterra)**

As a technical director for the lab, Dr. Medine developed a thorough peer review program to QA/QC all data leaving the laboratory, including data developed for the CLP program as well as for industrial clients for metals, volatile and semi-volatile organics, pesticides and other parameters.

**Client: State of Colorado- Department of Law**

He was the Quality Assurance Program Manager project manager and senior environmental engineer at four NRDA/CERCLA sites (two radioactive waste sites and two base metal mining sites) involving a full range of field operations designed to gather information for remedial technology application toward site cleanup. Field operation expertise includes site assessments, risk assessment, development of monitoring programs, contamination delineation, bioassessments, health & safety plans, sampling and analysis plans as well as data validation, reduction and interpretation. Senior engineering support included all aspects of the RI/FS/RD process and also included numeric contaminant transport modeling and expert testimony in federal court for the Idarado Mining and Milling facility. Modeling was used to determine maximum daily contaminant loadings (via load reductions) needed to restore the aquatic environment.

**University Research and Teaching Experience**

- 1988-1997 Guest Lecturer, CU, CSU and Colo. School of Mines.
- 1986-1988 Affiliate Associate Professor, Civil Engineering, Colorado State Univ.
- 1980-1984 Assistant Professor Civil Engineering, University of Colorado-Boulder

- 1978-1980 Assistant Professor Civil Engineering, University of Connecticut, Storrs, CT.
- 1975-1978 Research Assistant, Utah Water Research Lab, Logan.

Responsibilities at both the University of Colorado and at the University of Connecticut included teaching graduate and undergraduate level courses, environmental engineering research, student supervision, and organization and maintenance of the environmental engineering chemistry laboratories. Teaching experience, research publications and student research supervision are summarized in subsequent sections.

Dr. Medine developed, implemented and managed environmental engineering research programs and analytical laboratories at the University of Connecticut and the University of Colorado for 7 years as a faculty member in the Civil and Environmental Engineering Departments. These programs included numeric computer modeling fate and transport of metals in the environment, biological effects and environment restoration technologies. Research on relatively un-impacted natural systems included trace metal and nutrient source, transport, transformations and impact in the Colorado River Basin, Yellowstone National Park, and Canyonlands National Park. He recently completed research and development on a field-scale program for selenium migration control methods using a variety of constructed wetlands. Dr. Medine has served as major advisor for 6 graduate students (M.S. & Ph.D.) and has been a committee member for over one dozen Ph.D. Candidates and 30 Masters candidates in the fields of Civil & Environmental Engineering, Chemistry, Biological Sciences, Agricultural Engineering and Geological Sciences.

**Graduate Level Courses:** - taught at Colorado State University, Univ. of Colorado-Boulder, and at Univ. of Connecticut-Storrs while on the faculty:

#### **ENVIRONMENTAL**

Aquatic Chemistry: process, chemical modeling, geochemistry, environmental  
Fate and Effects of Pollutants and Hazard Assessments  
Hydrologic Simulation Methods in Environmental Engineering  
Contaminant Transport & Transformation Modeling  
Environmental Analysis Methods

#### **PROCESS THEORY AND DESIGN**

Advanced Wastewater  
Wastewater Treatment  
Advanced Water Treatment  
Unit Operations and Processes Pilot Plant Laboratories

#### **Client: U.S. Department of Energy**

He coordinated the Remedial Investigation Report with a staff of 35 for the Weldon Spring Site Remedial Action Project, MO., a DOE Mixed Waste Installation (U, Th, Ra, Rn, TNT, DNT, PCBs, Toluene, Metals), and provided senior support on the risk assessment, data validation, and applicable technologies for remedial action.

**Client: U.S. Navy**

He was the project manager for the San Pedro Fuel Oil Depot for site characterization and the PA for the project and also provided senior technical support on various phases of RI/FS/RA at the Yuma Marine Corp. Air Station under the Navy CLEAN program.

**Client: Keller Bliesner Engineering**

Engineering support, research and characterization of selenium releases from natural soils and migration to sensitive ecological environments. Other tasks included development of a conceptual model for contaminant transport and environmental chemistry support for the development of a numeric groundwater transport model to predict selenium migration for a 200 square mile irrigation project in the southwest and development and installation of a field-scale program for selenium migration control methods using a variety of constructed wetlands.

**Client: Ecosystem Research Institute**

Long-term technical environmental engineering support on environmental sampling, modeling, analytical chemistry, permitting and restoration.

**American Society of Civil Engineers.** Conference chairman for the 1983 National Conference on Environmental Engineering held in Boulder, CO and attended by over 400 professionals.

**Technical Workshops.** Dr. Medine developed workshops, prepared workshop material and personally conducted 10 national or regional workshops (7 for EPA) on various hazardous waste topics including setting and implementing water quality standards; chemical and instrumental analysis methods; speciation and transport modeling of contaminants and sediments in surface water and groundwater systems; total maximum daily loadings, metal contamination in natural systems; environmental monitoring programs; QA/QC; remedial technology assessments; and, controlling toxic chemical contamination in surface waters and groundwaters.

Geochemical Modeling with MINTEQ - Sept 1-3, 1987, Athens, GA for the U.S. Environmental Protection Agency (w/Brown, Westall, Wool and Dean).

Chemical Modeling with the Metals Equilibrium Speciation (MINTEQA1)-Aug 23-25, 1988, Boulder CO for the U.S. EPA (w/Brown, Westall, Wool).

Metal Contamination in Surface Waters: Methods for Assessment and Control - December 13-14, 1988, Denver, CO for the U.S. Environmental Protection Agency (Sole presenter).

Chemical Modeling with the Metals Equilibrium Speciation Model MINTEQA2 - Aug 22-24, 1989, Athens, GA for the U.S. Environmental Protection Agency (w/Brown, Westall).

Upper Arkansas Technical Workshop - Feb 13-14, 1989, Paper Presented titled "Geohydrologic Modeling With Reference to the Upper Arkansas," and Moderator for Geochemistry/Geohydrology Working Session.

Water Quality Workshop on Setting and Implementing Water Quality Standards - October 11-12, 1989, Washington, D.C., for the Utility Water Act Group (UWAG w/L. Tischler).

Assessment and Control of Toxic Metal Contamination in Groundwaters and Surface Waters - October 22-24, 1990, Dallas, TX for the U. S. EPA (Sole Presenter).

Prediction, Prevention and Control of Acid Mine Drainage in the Western United States - August 18-21, 1992, Breckenridge, CO for State of Colorado (Div. of Mines), Western Governors' Assn and U.S. EPA Region VIII (w/ Andy Robertson and Dave Blowes).

Geochemical Modeling with the Metals Equilibrium Speciation Model MINTEQA2 - July 11, 1994, Denver, CO for private groundwater consulting firm (Sole Presenter).

Water Quality Modeling With WASP4-META4: Metal Speciation, Transport, Transformations and Fate – September 11-12, 1996 for U.S. EPA Region VIII (Sole Presenter).

## HONORS, DISTINCTIONS

NCEES, Committee on Examination for Professional Engineering Registration (PE), 2002-present  
American Academy of Environmental Engineers, 1999-present  
American Men and Women of Science, 1998  
Who's Who in Executives and Professionals, 1998-1999  
Session Chairman, Superfund '92 and '93  
Who's Who Environmental Registry, 1992 to present  
Who's Who in Technology Today, 1980-1984, 1994  
Member ASCE Environ. Engr. Division Task Committee (Modeling)  
Member WEF (WPCF) Research Committee, 1982-1987  
Certificate of Appreciation, ASCE Environ. Engr., 1984  
Chairman, 1983 ASCE Nat. Conf. on Environmental Engineering, Boulder, CO  
Special Merit Award, University of Connecticut, 1979  
University James Scholar (with high honors), U of I, 1972

## RIVER BASIN EXPERIENCE

Dr. Medine has worked on environmental issues such as water quality violations, environmental sampling, contaminant loading analyses, waste site characterization, permitting, modeling, and resource restoration in numerous river basins in the United States including:

<b>COLORADO</b>	Colorado River, San Juan River, South Platte, Arkansas River, Delores River, Alamosa River, White River, Chalk Creek, Eagle River, Animas River, Clear Creek, California Gulch, San Miguel River, Uncompahgre River, Red Mountain Creek, Wightman Fork, Terrace Reservoir
<b>UTAH</b>	Colorado River, San Juan River, Green River, Lake Powell, White River, Jordan River, Bear River, Great Salt Lake, Canyonlands National Park, Bingham Creek
<b>IDAHO</b>	Salmon River, Snake River/Island Park, Payette River, Panther Creek, Blackbird Creek, Big Deer Creek, Horseshoe Bend, Coeur d'Alene River, Lake Coeur d'Alene
<b>MISSOURI</b>	Missouri River
<b>MONTANA</b>	Clark Fork River Basin, Milltown Reservoir, Belle Creek, Belle Fourche River, Little Powder River
<b>WYOMING</b>	Yellowstone River, Yellowstone Lake, Yellowstone Basin
<b>SOUTH DAKOTA</b>	Whitewood Creek
<b>KANSAS</b>	Marais des Cygnes River
<b>TEXAS</b>	Brazos River, San Jacinto River
<b>NEW MEXICO</b>	San Juan River, Red River
<b>PENNSYLVANIA</b>	Delaware River
<b>CONNECTICUT</b>	Naugatuck R.
<b>NEW JERSEY</b>	Chestnut Branch, Alcyon Lake

## **LITIGATION SUPPORT, EXPERT WITNESS TESTIMONY**

Dr. Medine has provided expert witness and litigation support to the government on over one dozen major hazardous water sites in areas such as contaminant source, transport and fate and remedial technology. Each case is summarized below:

**Site: Metal Bank Superfund Site, Philadelphia, PA / Delaware River**

**Attorney Eric Williams, Washington 202-305-0302**

Representing: Plaintiffs, Dept. of Justice, U.S. Government

Role: Expert Witness, Litigation/Technical Support

- Historical Contaminant Source and Release to Natural Systems
- Fate and Transport of Toxic Substances through soils, Water Quality
- Groundwater: Fate and Transport and Water Quality
- Sediment Transport and Hydrodynamics, Sediment Quality
- Liability Theories

Expert Reports Prepared, Trial Testimony Aug. -Sept., 2002

**Site: San Jacinto River, Houston, Texas**

**Attorney Patrick Casey, Washington 202-514-1448**

**Texaco Pipeline Failures and Major Oil Spills**

Representing: Plaintiffs, Dept. of Justice, U.S. Government

Role: Expert Witness, Litigation/Technical Support

- Historical Floodplain Geomorphology and Dynamics
- Hydrologic Evaluation and Flood Frequency
- Sediment Transport, Hydrodynamics and Cutoff Channel Formation

Expert Report Prepared, Case Settled

**Site: Lipari Landfill, New Jersey**

**Attorney Dan Beckhard, Washington 202-616-7921**

Representing: Plaintiffs, Dept. of Justice, U.S. Government

Role: Expert Witness, Litigation/Technical Support

- Fate and Transport of Toxic Substances
- Assessment of Releases of Hazardous Substances
- Surface Water and Groundwater Quality Assessment

Expert Reports Prepared, Deposition Taken, Case Settled

**Site: Clark Fork River Superfund Site, Montana**

**Attorney Sarah Himmelhoch, Washington 202-514-0180**

Representing: Plaintiffs, Dept. of Justice, U.S. Government

Role: Expert Witness, Litigation/Technical Support

- Historical Contaminant Source and Release to Natural Systems
- Fate and Transport of Toxic Substances, Water Quality
- Groundwater: Fate and Transport and Water Quality
- Sediment Transport and Hydrodynamics, Sediment Quality
- Liability and Apportionment Theories

Expert Report Prepared, Deposition Taken

**Site: Blackbird Mine Site, Cobalt, Idaho**

**Attorney Rachel Jacobson, Washington 202-514-5474**

Representing: Plaintiffs, U.S. Government, State of Idaho

Role: Expert Witness, Litigation/Technical Support

- NRDA (Natural Resource Damage Assessment & Restoration Analysis)

- Water Quality, Modeling Fate and Transport of Toxic Substances
  - Environmental Effectiveness of Remedial Technologies
  - Engineering Technology for Hazardous Waste Remediation
  - Surface Water Quality and Restoration Assessment
- Case Settled

**Case: State of Colorado v. Idarado Mining**

**Idarado Mining and Milling Facility**

Representing: Plaintiffs, State of Colorado

Role: Expert Witness, Litigation/Technical Support

- Environmental Chemistry (Surface Water, Groundwater, Soil)
- Modeling Fate and Transport of Toxic Substances
- Quality Assurance/Quality Control in Analytical Data
- Environmental Effectiveness of Remedial Technologies
- Construction Sequencing and Environmental Protection
- Engineering Technology for Hazardous Waste Remediation

Trial: United States District Court, Judge Carrigan, Denver, CO April, 1987.

**Case: U. S. Government v. Resurrection Mining, ASARCO, et al.**

**California Gulch Superfund Site**

Representing: Plaintiffs, Dept. of Justice, U.S. Government (&EPA)

Role: Expert Witness, Litigation/Technical Support

- Liability for Contaminant Releases
- Water Quality, Modeling Fate and Transport of Toxic Substances
- Assessment of Environmental Quality, Ecological Risk Assessment
- Environmental Effectiveness of Remedial Technologies
- Engineering Technology for Hazardous Waste Remediation

Case Settled

**Case: City of Lakewood v. Various Insurance Companies**

**Lowry Landfill Superfund Site**

Representing: Plaintiffs, City of Lakewood

Role: Expert Witness, Litigation/Technical Support

- Background & Nature of the Superfund Process
- CERCLA Action at the Lowry Landfill
- Environmental Contamination at Lowry, Leachate Formation Processes
- Environmental Regulations and Commonly Used Disposal Practices
- Wastewater Treatment Technology, Sludge Generation and Quality

Deposition Taken, Case Settled

**Site: Fike/Artel Superfund Site, West Virginia**

Representing: Plaintiffs, Dept. of Justice, U.S. Government

Role: Expert Witness, Litigation/Technical Support

- Fate and Transport of Toxic Substances
- Assessment of Historical Releases of Hazardous Substances
- Allocation Methodology

Expert Report Prepared, Case Settled

**Site: Sharon Steel Site, Pennsylvania**

Representing: Plaintiffs, Dept. of Justice, U.S. Government

Role: Expert Witness, Litigation/Technical Support

- Remediation Technologies and Cost Analysis

Case Settled

**Site: Arlington Packaging and Blending Site, Tennessee**

Representing: Plaintiffs, Dept. of Justice, U.S. Government and Plaintiffs, Terminex

Role: Expert Witness, Litigation/Technical Support

- Source, Fate and Transport of Toxic Substances
- Soils, Groundwater and Surface Water Contamination
- Remediation Technology Assessment and Divisibility

Expert Report Prepared, Deposition Taken, Case settled

**Site: Bingham Canyon Site, Utah**

Representing: Plaintiffs, Dept. of Justice, U.S. Government

Role: Expert Witness, Litigation/Technical Support

- Historical Contaminant Source and Release to Natural Systems
- Fate and Transport of Toxic Substances, Water Quality
- Sediment Transport and Hydrodynamics, Sediment Quality

Case Settled

**Site: City of Lakewood Groundwater TCE Contamination, Quality Metal Products**

Representing: Plaintiffs, City of Lakewood, Colorado

Role: Expert Witness, Litigation/Technical Support

- Source, Fate and Transport of Toxic Substances
- Groundwater and Surface Water Contamination

Expert Report Prepared, Deposition Taken, Case settled

**Site: ASARCO Globeville Facility / Case: C. DeBaca et al. vs. ASARCO, Inc.**

Representing: Plaintiffs, Proposed C. DeBaca class

Role: Expert Witness, Litigation/Technical Support

- Environmental Chemistry (Surface Water, Groundwater, Soil)
- Environmental Effectiveness of Remedial Technologies
- Engineering Technology for Hazardous Waste Remediation

Certification Hearing: U.S. District Court/City and County of Denver, 10/98, Judge Hoffman,  
Class Certified, Liability Case Settled

**Site: Summitville Mine Site, Colorado**

Representing: Plaintiffs, Dept. of Justice, U.S. Government

Role: Expert Witness, Litigation/Technical Support

- Historical Contaminant Source and Release to Natural Systems
- Fate and Transport of Toxic Substances, Water Quality
- Groundwater: Fate and Transport and Water Quality
- Sediment Transport and Hydrodynamics, Sediment Quality
- Liability and Apportionment Theories

Expert Report Prepared, Deposition Taken

**Site: Krejci Dump Site, Cayahoga National recreation Area, OH**

Representing: Plaintiffs, Dept. of Justice, U.S. Government

Role: Expert Witness, Litigation/Technical Support

- Historical Contaminant Source and Release to Natural Systems
- Fate and Transport of Toxic Substances
- Liability

Expert Report Prepared, Deposition Taken, Case settled

## **HAZARDOUS WASTE SITE EXPERIENCE (Non-Litigation Technical Support)**

### **Weldon Spring Site Remedial Action Project, MO**

DOE Installation-Mixed Waste: U, Th, Ra, Rn, TNT, DNT, PCBs, Toluene, Metals; Coordinated Remedial Investigation and provided senior support on risk assessment, data validation, and applicable technologies for remedial action.

### **Sheridan Disposal Services Superfund Site, TX**

Multiple PRP Organic Waste Disposal: PCBs, Metals, Benzene, Ethylbenzene, Phenanthrene, TCE, and numerous others; Project Manager for Jacobs contractor oversight for treatability studies, FS, Remedial Design and Remedial Action and technical negotiations.

### **Wasatch Chemical, Salt Lake City, UT**

Pesticide contamination, provided initial site inspection and state sampling oversight.

### **NAVY Defense Fuel Supply Station, San Pedro, CA**

Fuel Supply Depot, Petroleum Products, Pesticides, Solvents; Project Manager for RI/FS and Risk Assessment and Communication.

### **NAVY, Yuma Marine Corp Air Station CERCLA Site, AZ**

Fuels, Solvents, metals; Field Investigation for Soils Contamination, RI/FS workplan review.

### **Chemplex Superfund Site, KS**

Multiple PRP Organic Waste Disposal: Metals, Benzene, Ethylbenzene, Phenanthrene, TCE, and numerous others; senior engineer for contractor oversight for treatability studies involving, stabilization/solidification (S/S), solvent extraction, bioremediation, incineration, air stripping and thermal degradation.

### **Champion International Superfund Site, Libby, MT**

Wood Products Treating: PAHs Pentachlorophenol, Technical review of design of Land Treatment Disposal Unit for biological degradation treatment of soils, QA/QC and No-Migration Petition.

### **Whitewood Creek, Homestake Mining Superfund Site, SD**

Gold-Mining: Primarily As and Cd in tailings along with Se, Zn, Cu, Mn, Fe, etc.; Technical enforcement support for Risk Assessments prepared by PRPs, Senior Technical Manager for Risk Assessments, ROD, Feasibility Study, Remedial Design/Remedial Action. Developed remedial design documents and Construction QA/QC Plan.

### **Marshall Landfill Superfund Site, Boulder, CO**

Municipal Landfill: Solvents, Metals. Reclamation and Closure Design EPA support.

### **California Gulch Superfund Site, CO**

Metal mining, milling and smelting; Technical report on slag composition, leachability and potential risks for human and environmental impacts, contaminant transport modeling, chemical modeling of cleanup effectiveness.

### **Cotter Corp. Uranium Mill CERCLA Site, Canon City, CO.**

Technical Review of the Status of Natural Resources Damages. Major author of Remedial Investigation, Feasibility Study and Remedial Action Plan.

**ASARCO Metals Processing Facility CERCLA Site, Globeville (Denver).**

Natural Resource Damage Assessment, field investigation of soils, sediment and surface water contamination.

**Uravan Uranium Mill CERCLA Site, Uravan, CO**

Managed Winter Baseline Investigation of Surface Media (Historical Information and Field Investigation of soils, sediments and surface water). Developed Remedial Action Plan.

**RTZ Ltd., Kennecott, UT**

Metal mining, processing and smelting: As, Cu, Se, others; Environmental Assessment at Kennecott Copper and complete environmental review.

**Confidential Client**

**Stapleton International Airport, CO**

Petroleum Products, Solvents, Glycols; Project Manager for Phase I Environmental Assessment and detailed Phase II assessment.

**Clear Creek Superfund Site, CO**

Metals, principally Zn, Cd, Pb, Cu; EPA support contractor for environmental modeling, environmental risk assessment, remedial action and the development of site characterization programs.

**Eagle Mine NPL Site, CO**

Metals, principally Zn, Cd, Pb, Cu, Ag; EPA support on interpretation of surface water contamination, toxic metal transport and transformations, environmental modeling, environmental risk assessments, and remedial action.

**DOE Rocky Flats Plant, CO**

Program manager for WALSH in the support of soils, soil-gas and Health and Safety services to Stoller Corp. at OU7.

**Elmendorf Air Force Base. AK**

Petroleum Products, solvents, explosives; Technical support on quality assurance, analytical requirements, bioremediation, and data needs for treatability studies and construction of bioremediation facilities for contaminated soils.

**Sand Creek Industrial Superfund Site, Denver, CO**

Technical support/review of the RI/FS prepared by EPA Contractor for Operable Unit 4: Local & Regional Groundwater Resources.

**Summitville Mine Site, Alamosa, CO**

Technical support to U.S. EPA on Pre-mining and Pre-industry environmental quality and modeling contaminant transport and transformations in surface waters and sediments Site characterization sampling and technical support on the RI/FS.

**Mystery Bridge/U.S. Highway 20, WY**

Petroleum Products, solvents; Technical review of RI/FS and remedial action documents concerning soils and groundwater contamination

**Sioux City Airport, IA**

Petroleum Products; soil and groundwater contamination and remediation

Additional EPA mining site experience includes technical support for the Clark Fork, Animas River, and Jordan River. Support at the Idarado Mining and Milling, Lowry Landfill, Blackbird Mine, Sharon Steel Site, Lipari Landfill, Fike/Artel, Arlington Packing and Blending, Bingham Creek, Clark Fork River and other sites is listed under Litigation Support.

## **PUBLICATIONS**

Dr. Medine has published over two dozen technical papers and prepared over 40 technical reports on a variety of environmental engineering subjects. He has also presented numerous seminars, invited papers and technical papers at national and international conferences and symposia and chaired sessions at various conferences. **Expert reports prepared for litigation are not listed.**

## **BOOKS, MONOGRAPHS, SYMPOSIA (Peer Reviewed)**

Medine, A.J., D.B. Porcella and V.D. Adams. 1980. Heavy Metal and Nutrient Effects on Sediment Oxygen Demand in Three-Phase Aquatic Microcosms, pp. 279-303. In: Microcosms in Ecological Research. J.P. Giesy (Ed.), Dept. of Energy, Symposium Series #52, CONF 781101.

Medine, A.J. and D.B. Porcella. 1980. Heavy Metal Effects on Photosynthesis / Respiration of Microecosystems Simulating Lake Powell, UT/AZ, pp. 355-390. In: Contaminants and Sediments, R.A. Baker (Ed.), Ann Arbor Science, Michigan.

Medine, A.J. 1983. Potential Impacts of Energy Development Upon Water Quality of Lake Powell and the Upper Colorado River, pp. 397-424. In: Aquatic Resources Management of the Colorado River Ecosystem. Proceedings of a Symposium on Nov. 16-19, 1981. Las Vegas, Nevada. V. Dean Adams and Vincent A. Lamarra (Eds.), Ann Arbor Science, Michigan.

Medine, A.J. and M.A. Anderson (Editors). 1983. National Conference on Environmental Engineering. Proceedings of a conference held in Boulder, CO, July 6-8, ASCE, NY.

Medine, A.J. and B.R. Bicknell. 1986. Case Studies and Model Testing of the Metals Exposure Analysis Modeling System (MEXAMS). U.S. EPA, Athens, GA EPA-600/3-86-045, 224 pp.

Medine, A.J. and McCutcheon, S. C. 1989. Fate and Transport of Sediment Associated Contaminants. In: Hazard Assessment of Chemicals - Current Developments, Volume 6, Jitendra Saxena, Editor, Hemisphere Publishing Corp.

Medine, A.J. and Martin, J.L. 2002. Development of the Metal Speciation-based Metal Exposure and Transformation Assessment Model (META4): Application to Copper and Zinc Problems in the Alamosa River, Colorado. In: Fate and Transport of Chemicals in the Environment: Impacts, Monitoring and Remediation. R.L. Lipnick, R.P. Mason, M.L. Phillips, and C.U. Pittman (Eds.) ACS Publications, Washington.

## **CONFERENCE PROCEEDINGS**

Medine, A.J., V.A. Lamarra and J.G. Carter. 1983. Heavy Metal Distribution and Interactions in the White River Ecosystem. Proceedings of the 1983 ASCE National Conf. on Environmental Engineering, ASCE, NY, NY.

Lamarra, V.A., A.J. Medine and J.G. Carter. 1983. The Development of Methodologies for the Restoration of Aquatic Ecosystems. Proceedings of the 1983 ASCE National Conf. on Environmental Engineering, ASCE, NY, NY.

Medine, A.J. and Lamarra, V.A. 1984. Simulation of Metal Fate and Transport in Rivers with MEXAMS. Proceedings of the 1984 National Conf. on Environmental Engineering, ASCE, NY, NY.

Medine, A. and Willingham, T. 1990. Water Resource Management Strategies for Restoring and Maintaining Aquatic Life Uses. Intern'l Symposium on Fish Toxicology, Physiology and Water Quality Management, Joint EPA/PRC, Sacramento, Oct, 1990.

Medine, A.J. and Martin, J.L. 2002. Development of a Metal Exposure and Transformation Assessment Model for Use in Watershed Management and TMDL Analyses. Proceedings of Watershed 2000, Water Environment Federation and British Columbia Water and Waste Association and Western Canada Water and Wastewater Association, July 8-12

Medine, A.J. and Martin, J.L. 2000. Development of the Metal Speciation-based Metal Exposure and Transformation Assessment Model (META4): Application to Copper and Zinc Problems in the Alamosa River, Colorado. Proceedings of the ACS National Meeting, Environmental Chemistry Division Symposium entitled "Emphasis on EPA and EPA-Supported Research", Washington, D.C., August 21-25, 2000.

#### **JOURNAL ARTICLES**

Porcella, D.B. and A.J. Medine. 1979. Eutrophication. J. Water Pollut. Control Fed., 51:1455-1462.

Medine, A.J. and D.B. Porcella. 1980. Eutrophication. J. Water Pollut. Control Fed., 52:1511-1519, 53:908-916.

Medine, A.J. and D.B. Porcella. 1982. Eutrophication. J. Water Pollut. Control Fed., 54:915-922.

Porcella, D.B., V.D. Adams, A.J. Medine and P.A. Cowan. 1982. Using Three-Phase Aquatic Microcosms to Assess Fates and Impacts of Chemicals in Microbial Communities. Water Research, 16:489-496.

Medine, A.J. and M.A. Anderson. 1983. Eutrophication. J. Water Pollut. Control Fed., 55:757-764.

Medine, A.J. and V.A. Lamarra. 1984. Eutrophication. J. Water Pollut. Control Fed., 56:697-704.

Medine, A.J. and V.A. Lamarra. 1985. Lake Management. J. Water Pollut. Control Fed., 57:965-972.

Medine, A.J., V.A. Lamarra and T. Barnard. 1986. Lake and Reservoir Management. J. Water Pollut. Control Fed., 58:610-618.

Hirsch, A.H. and A.J. Medine. 1987. Lake and Reservoir Management. J. Water Pollut. Control Fed., 59:494-512.

Flack, J.E., A.J. Medine and K. J. Hansen-Bristow. 1988. Stream Water Quality in a Mountain Recreation Area. Mountain Research & Development, 8, 11-22.

## **TECHNICAL REPORTS · Expert Reports Prepared for Litigation are not Listed**

Medine, A.J., D.B. Porcella and P.A. Cowan. 1977. Microcosm Dynamics and Response to a Heavy Metal Loading in a Lake Powell Sediment-Water-Gas Ecosystem. Prepared for Southern California Edison Co., Contract No. U0966901, March.

Medine, A.J., D.B. Porcella and V.D. Adams. 1978. Nutrient Inactivation by Aluminum: Response and Evaluation in a Three-Phase Aquatic Microcosm.

Medine, A.J. 1980 DISSERTATION. The Use of Microcosms to Study Aquatic Ecosystem Dynamics - Methods and Case Studies. Utah State University, Logan, Utah. 354 pp.

Medine, A.J. and M.F. Conway. 1982. Heavy Metal Interactions and Dynamics in the Summit Impoundment on the Naugatuck River, CT, OWRT, A-087 CONN.

Flack, J.E., A.J. Medine and K. Hansen-Bristow. 1984. Effectiveness of Aspen Stands in Protecting Stream Water Quality from Recreation-Related Pollutants / Part I: Stream Water Quality in a Mountain Wilderness Area. Completion Report. Eisenhower Consortium for Western Environmental Forestry Research, U.S.F.S., U.S. Dept. of Agriculture (April).

Ecosystem Research Institute. 1984. The Spatial and Temporal Dynamics of Selected Heavy Metals in the White River - A Special Study. Prepared for White River Shale Oil Corporation, Salt Lake City, UT. (contact, ERI, Logan, UT).

Medine, A.J. 1985. Simulation of Metal Behavior in the Naugatuck and White Rivers. Case Studies Using the Metals Exposure Assessment Modeling System (MEXAMS). Prepared for Anderson-Nichols, Inc. as a subcontract to an EPA Project. 179 pp.

ERI - LOGAN, Inc. 1985. Technical Review of the Status of Natural Resources at the Cotter Corporation Uranium Mill Site in Canon City, CO. Prepared for Geotrans, Inc. and RMC.

ERI - LOGAN, Inc. 1985. Quality Assurance Project Plan for Sample Collection, Processing and Analysis. Prepared for The State of Colorado, Department of Law, Office of the Attorney General, CERCLA Section. With Geotrans, RMC, Engineering Science, Inc. and Rocky Mountain Analytical Laboratory.

Geotrans, Inc., RMC, Inc. and ERI LOGAN, Inc., 1985. ASARCO Globe Metals Processing Facility. A Preliminary Report Related to Natural Resource Damage. Prepared for The State of Colorado, Department of Law, Office of the Attorney General, CERCLA Section.

Geotrans, Inc., RMC, Inc. and ERI LOGAN, Inc., 1985. Cotter Corp. Uranium Mill Site. A Preliminary Report Related to Natural Resource Damage. Prepared for The State of Colorado, Dept. of Law, Office of the Attorney General.

Geotrans, Inc., RMC, Inc. and ERI LOGAN, Inc., 1985. Idarado Mining and Milling Complex. A Preliminary Report Related to Natural Resource Damage. Prepared for The State of Colorado, Dept. of Law, Office of the Attorney General, CERCLA Section.

Geotrans, Inc., RMC, Inc. and ERI LOGAN, Inc., 1985. Cotter Corp. Uranium Mill Site. An Interim Report Related to Natural Resource Damage. Prepared for The State of Colorado, Dept. of Law, Office of the Attorney General, CERCLA Section.

ERI LOGAN, Inc. 1986. Background Information for Setting Remedial Action Performance Standards, Draft No. 1. Prepared for The State of Colorado, Department of Law, Office of the Attorney General, CERCLA Section.

ERI LOGAN, Inc. 1986. Winter Baseline Investigation of Surface Media in the Vicinity of the Uravan Uranium Mill, Uravan, Colorado. Volume I: Results of January 1986 Field Investigation. Prepared for The State of Colorado, Department of Law, Office of the Attorney General, CERCLA Section, 213pp.

ERI LOGAN, Inc. 1986. Winter Baseline Investigation of Surface Media in the Vicinity of the Uravan Uranium Mill, Uravan, Colorado. Volume II: Summary of Historical Information. Prepared for The State of Colorado, Department of Law, Office of the Attorney General, CERCLA Section, 206pp.

Geotrans, Inc., RMC, Inc. and ERI LOGAN, Inc., 1986. Idarado Mining and Milling Complex - Remedial Investigation. Prepared for The State of Colorado, Dept. of Law, Attorney Generals Office, CERCLA Section.

Geotrans, Inc., RMC, Inc. and ERI LOGAN, Inc., 1986. Idarado Mining and Milling Complex - Feasibility Study. Prepared for The State of Colorado, Department of Law, Office of the Attorney General, CERCLA Section.

Geotrans, Inc., RMC, Inc. and ERI LOGAN, Inc., 1986. Cotter Corporation Uranium Mill Site - Remedial Investigation. Prepared for The State of Colorado, Department of Law, Office of the Attorney General, CERCLA Section.

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Remedial Action Plan, 1987. Uravan Uranium Mill, Uravan, CO

Remedial Action Plan, 1987. Cotter Uranium Mill, Canon City, CO.

Medine, A.J. and Howbert, J. 1988. Environmental Assessment at Belle Creek, MT., a 26 Square Mile Oil Production Facility containing over 900 production wells and 12 tank batteries, prepared for Exxon Co., USA.

Jacobs Engineering Group, 1989. Phase I Final Report for Environmental Assessment Activities at Stapleton International Airport. Prepared for Davis, Graham and Stubbs, November 7.

Medine, A.J. 1989. Water Quality Assessment for the Animas River Basin. Prepared for the U.S. EPA, Environmental Research Lab., Athens, GA and Region VIII.

Medine, A.J. 1991. Assessment of Contaminant Source, Transport, Transformations and Impact in the Eagle River: Conceptual Model for Contaminant Dynamics. Prepared for the U.S. EPA, RREL START Program, Cincinnati, OH and Region VIII.

Medine, A.J. 1991. Technical report on Metal Source, Transformations, Speciation and Modeling in the Clear Creek Basin. Prepared for the U.S. EPA, RREL START Program, Cincinnati, OH and Region VIII.

Medine, A.J. 1992. Contaminant Transport Modeling In The Mainstem Of The Clear Creek Basin. Prepared for IT Corporation, Cinn. for the EPA Clear Creek Superfund Site.

Medine, A. J. 1992. Surface Water Monitoring Program For The Clear Creek Basin. Prepared for IT Corporation, Cinn. OH under support to the EPA Clear Creek Site.

Medine, A.J. 1992. Modeling Zinc Water Quality For North Clear Creek In Response To Water Supply Diversions. Prepared for IT Corporation Cinn. for the EPA Clear Creek CERCLA Site.

Medine, A.J. 1992. Contaminant Transport Modeling In The Clear Creek Basin: North Clear Creek System. Prepared for IT Corporation, Cinn. for the EPA Clear Creek Superfund Site.

Medine, A.J. 1992. Sampling And Analysis Plan For Chemical, Physical And Biological Assessment: North Clear Creek. Prepared for IT Corp., Cinn., Ohio under support to the EPA Clear Creek Superfund Site.

Medine, A. J. 1992. Analysis of the carbonate system Dynamics of the Ground Water-surface Water System, Barrick Goldstrike Mines, Elko, Nevada. Prepared for Keller-Bliesner Engineering, Logan, UT.

Medine, A.J. 1993. Contaminant Transport Modeling in the Mainstem of the Clear Creek Basin: EPA MOD-4 Version, Technical Memorandum. Prepared for IT Corp., Cinn., Ohio under support to the EPA Clear Creek Superfund Site.

Medine, A. J. 1994. Treatability Study for Assessment of Potential Improvement in Water Quality of the Animas River. Prepared for the Water Quality Management Division, State of Colorado.

Medine, A. J. 1994. Conceptual Model and the Development of a Contaminant Transport Model for Metals in California Gulch. Prepared for USEPA, Risk Reduction Engineering Research Laboratory under subcontract to IT Corporation.

Medine, A. J. 1994. Sediment Sampling and Analysis Plan for Chemical and Physical Assessment of North Clear Creek, Clear Creek Superfund Site. Prepared for USEPA, Risk Reduction Engineering Research Laboratory under subcontract to IT Corporation.

Medine, A. J. 1994. Evaluation of Sediment Porewater Concentrations for Zinc, Cadmium, Copper and Lead in California Gulch and the Arkansas River. Prepared for USEPA, Risk Reduction Engineering Research Laboratory under subcontract to IT Corporation.

Medine, A.J. 1994. Conceptual Model for selenium Source, Transformations, Migration and Impact, Navaho Indian Irrigation Project (NIIP), Prepared for Keller-Bliesner Engineering, Logan, Utah.

Medine, A. J. 1995. Chemical and Physical Assessment of North Clear Creek During July 1994. Prepared for USEPA, Risk Reduction Engineering Research Laboratory under subcontract to IT Corporation.

Medine, A. J. 1996. Chemical, Physical and Biological Assessment of Clear Creek and Selected Tributaries in the Clear Creek Basin During Fall 1995. Prepared for USEPA, Risk Reduction Engineering Research Laboratory under subcontract to IT Corporation.

Medine, A. J. 1996. Development of Stormwater Runoff and Water Quality Modeling Capabilities for the Stray Horse Gulch Basin. Prepared for USEPA, National Risk Management Reduction Laboratory under subcontract to SAIC.

Medine, A.J. 1996. Modeling the Water Quality Impacts of Transbasin Diversions on North Clear Creek Prepared for USEPA, National Risk Management Reduction Laboratory under subcontract to IT.

Medine, A. J. 1996. Modeling the Improvement in Water Quality from Remedial Action at the Apache Tailings in California Gulch. Prepared for USEPA, National Risk Management Reduction Laboratory under subcontract to IT Corporation.

Medine, A. J. 1997. Calibration of WASP4/META4 to Contaminant Transport in the Mainstem of Clear Creek. Prepared for USEPA, National Risk Management Reduction Laboratory, OH.

Medine, A.J. 1997, Calibration and Application of WASP4/META4 to Contaminant Transport and Water Quality Problems in North Clear Creek. Prepared for USEPA, National Risk Management Research Laboratory, Cincinnati, OH.

Medine, A. J. 1997. Technical Assessment of Pre-Mining and Pre-Galactic Water Quality for Wightman Fork and the Alamosa River. Prepared for USEPA, National Risk Management Research Lab., Cincinnati, OH.

Medine, A. J. 1999. Variable pH Simulation Capabilities for the Metal Exposure and Transformation Assessment Model: META4 Version 3. Prepared for USEPA, National Risk Management Research Laboratory, Cincinnati, OH, May 25.

Medine, A. J. 1999. Simulation of Water Quality Effects of Sediment and pH Control in North Clear Creek Using WASP4/META4. Prepared for USEPA, National Risk Management Research Laboratory, Cincinnati, OH, January 8.

Medine, A. J. 1999. Model Development and Simulation of Metal Dynamics in Terrace Reservoir on the Alamosa River. Prepared for USEPA, National Risk Management Research Laboratory, Cincinnati, OH, December, 2000.

Medine, A.J., 2001. The Significance of Contaminated Sediments Within Sub-Drainages of the North Fork Clear Creek Watershed to Water Quality Issues. Prepared for Colorado Dept. of Public Health / Environment Hazardous Materials / Waste Management Division Mr. Ron Abel, Project Manager, Denver, CO February.

Medine, A.J., 2003. Modeling the Effectiveness of Remedial Alternatives at the Summitville Mine Superfund Site on Water Quality of the Alamosa River and Terrace Reservoir, prepared for the Colorado Dept. of Public Health and Environment, February.

#### **CERTIFICATIONS:**

Registered Professional Engineer: Colorado. No. 29856

Diplomate, American Academy of Environmental Engineers with Hazardous Waste Specialty Certification

OSHA 29CFR 1910.120, 40-Hour Hazardous Waste Training, refresher current in 2003

OSHA 8-Hour Supervisor Training.

#### **PROFESSIONAL SOCIETIES**

Water Environment Federation

International Association on Water Quality (IWA)

American Chemical Society and Div. of Environmental Chemistry

American Academy of Environmental Engineers

American Society of Civil Engineer

United States of America and The State of Ohio v. AK Steel Corporation

Civil Action No. C-1-00530  
United States District Court  
Southern District of Ohio, Western Division

**DRAFT** EXPERT REPORT:

SURFACE-WATER and GROUND-WATER CONTAMINATION  
AT THE AK STEEL WORKS  
MIDDLETOWN, OHIO

prepared for the  
U.S. Department of Justice  
Environmental Enforcement Section  
Washington, DC

by  
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## TABLE OF CONTENTS

### i. List of Figures

v

### ii. List of Tables

v

### iii. List of Appendices

v

### iv. List of Acronyms

v

## 1.0 INTRODUCTION

1-1

### 1.1 Identification of Expert

1-1

### 1.2 Information Relied Upon for Factual Background

1-1

## 2.0 NATURAL SETTING

2-1

### 2.1 Surface Water Hydrology

2-1

### 2.2 Geology 2-2

### 2.3 Hydrogeology

2-4

#### 2.3.1 Site-wide Hydrogeologic Model

2-4

#### 2.3.2 Slag Processing Area Perched Unit

2-6

#### 2.3.3 Vertical Ground-water Flow

**Contaminants Released to Surface Water and Ground Water at AK Steel**

????????????????????????????????????

2-8

**3.0 POTENTIAL OR ACTUAL SOURCES**

3-1

**3.1 Facility Description**

3-1

**3.1.1 The Melt Area**

3-1

**3.1.1.1 Cokemaking** 3-2

**3.1.1.2 Ironmaking** 3-5

**3.1.1.3 Sinter Plant** 3-6

**3.1.1.4 Steelmaking** 3-7

**3.1.2 South Plant Area**

3-8

**3.1.2.1 Steel Forming** 3-8

**3.1.2.2 Steel Finishing** 3-10

**3.1.2.3 Materials Handling** 3-11

**3.1.3 North Plant Area-Steel Finishing**

3-11

**3.1.4 Coil Paint Area-Steel Finishing**

3-12

**3.1.5 Slag Processing Area**

3-13

**3.1.6 Unspecified Locations**

3-14

**3.2 Evidence of Releases**

3-14

**3.2.1 Melt Plant** 3-16

**3.2.1.1 Coke Oven Gas Pipeline Leak** 3-18

**3.2.1.2 Coal Tar/Benzene Release** 3-22

**Contaminants Released to Surface Water and Ground Water at AK Steel**

????????????????????????????????????

3.2.1.3 Flushing Liquor Spills to Land	3-24
3.2.1.4 Robin Hood (K087-sprayed) Coal Storage Pile Area	3-24
3.2.1.5 Diesel Spill in Train Derailment	3-26
3.2.2 South Plant Area	
3-27	
3.2.2.1 Spent Pickle Liquor Spills to Land	3-27
3.2.3 North Plant Area	
3-28	
3.2.3.1 TCE in Well GM-27S	3-29
3.2.4 Coil Paint Area	
3-31	
3.2.5 Slag, Mill Scale, and Waste Processing Area	
3-33	
3.2.5.1 Concrete-pad Mounted Transformer PCBs	3-35
3.2.5.2 Pole-mounted Transformer PCBs	3-36
3.2.5.3 Mill Scale Area 2 PCBs	3-36
3.2.5.4 Mill Scale Area 3 and Landfill SWMU 40 PCBs	3-37
3.2.5.5 Northwest Corner SWMU 39 (South Landfill) PCBs	3-40
3.2.5.6 East Side SWMU 39 (South Landfill) PCBs	3-41
3.2.5.7 Former Oil Separator Ponds PCBs	3-44
3.2.5.8 Former Drainage Swale PCBs	3-45
3.2.5.9 Monroe Ditch and Dick's Creek PCBs	3-47
3.2.5.10 Unidentified Sources	3-49
3.2.6 NPDES Outfalls	
3-51	
3.2.6.1 Great Miami River	3-52
3.2.6.2 Dick's Creek	3-53
3.2.6.3 North Branch Dick's Creek	3-54

**4.0 DISCUSSION AND OPINIONS**

4-1

***Contaminants Released to Surface Water and Ground Water at AK Steel***

**??**

4.1 Releases to Onsite Environmental Media

4-1

4.2 Releases Known to Be Escaping Offsite

4-6

5.0 REFERENCES

5-1

5.1 Site-Specific

5-1

5.2 General 5-9

??

## **i. List of Figures**

Figure 2-1. Regional Setting of Armco Plant, Middletown, Ohio (Geraghty & Miller, Inc. May 89 Fig. 2)

Figure 2-2. Location of Buried Valleys (Geraghty & Miller, Inc. May89 Fig. 1)

Figure 2-3. Bedrock Topography Map (Geraghty & Miller, Inc. May89 Fig. 20)

Figure 2-4. Potentiometric Map of the Upper Aquifer, April 2001 (Arcadis 05Sep01 Fig. 1)

Figure 2-5. Potentiometric Map of the Intermediate Aquifer, April 2001 (Arcadis 05Sep01 Fig. 2)

Figure 2-6. Potentiometric Map of the Lower Aquifer, April 2001 (Arcadis 05Sep01 Fig. 3)

Figure 3-1. Iron and Steel Manufacturing Process Overview (USEPA Sep95 Exh. 3)

Figure 3-2. AK Steel Company Middletown Plant Process Flow Diagram (USEPA Aug97 Fig. 1-2)

Figure 3-3. AK Steel Middletown Works Layout Map <Does anyone have a decent one showing the various facilities?>

Figure 3-4. Iron and Steel Manufacturing Cokemaking and Ironmaking (USEPA Sep95 Exh. 4)

Figure 3-5. By-product Recovery Cokemaking Process Diagram (USEPA Apr02 Fig. 5-5)

Figure 3-6. Iron and Steel Manufacturing Steelmaking (USEPA Sep95 Exh. 5)

Figure 3-7. Forming and Finishing Operations (USEPA Sep95 Fig. 5-2)

Figure 3-8. Soil and Groundwater Investigation Monitoring Well and Soil Boring Network Configuration (Arcadis 08Feb02 Fig. 4)

## **ii. List of Tables**

Table 3-1. Trichloroethene in Intermediate Aquifer Well GM-27S

## **iii. List of Appendices**

Appendix A. Resume of Gary R. Chirlin

Appendix B. List of Testimony of Gary R. Chirlin

Appendix C. Publications of Gary R. Chirlin during the previous 10 years

Appendix D. Compensation of Gary R. Chirlin for this project

## **iv. List of Acronyms**

AO	administrative order
AOC	Area(s) of Concern
APC	air pollution control
bgs	below ground surface

## Contaminants Released to Surface Water and Ground Water at AK Steel

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BOF	basic oxygen furnace
BTEX	benzene, toluene, ethylbenzene, and xylenes
CAA	Clean Air Act
CCA	Cox-Colvin & Associates, Inc.
COG	coke oven gas
CWA	Clean Water Act
12DCE	1,2-dichloroethene (total)
DNAPL	dense nonaqueous phase liquid
EGL	electrogalvanizing line
ft	feet
ft/d	feet per day
gpd	gallons per day
gpm	gallons per minute
G&M	Geraghty & Miller, Inc.
HCl	hydrochloric acid
IMS	International Mill Services, Inc.
MEK	methyl ethyl ketone, or 2-butanone
MGD	million gallons per day
msl	mean sea level
NAPL	nonaqueous phase liquid
OEPA	Ohio Environmental Protection Agency
OHS	open-hearth furnace
OMS	Olympic Mill Services
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
ppb	parts per billion
PIR	Pollution Incident Report
ppm	parts per million
PR	Preliminary Review
PRW	pickle rinse water
RCRA	Resource Conservation and Recovery Act
RM	river mile
SDWA	Safe <span style="background-color: black; color: red;">non-responsive</span> Water Act
SPCC	spill prevention control and countermeasure
SPL	spent pickle liquor
SV	Sampling Visit (in the sense of PRC [11Dec92 pg. 2])
SWMU	Solid Waste Management Unit
111TCA	1,1,1-trichloroethane
TCE	trichloroethene
TSCA	Toxic Substances Control Act
UIC	Underground Injection Control
USEPA	United States Environmental Protection Agency
VSI	Visual Site Inspection

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## **1.0 INTRODUCTION**

The United States has selected Chirlin & Associates, Inc. (CAI) to provide testimony concerning the occurrence, distribution, and fate of chemical contamination at the AK Steel Facility, Middletown, Ohio ("Site").<sup><1></sup>

The objective of the work reported here is to form and document an expert opinion on the following two issues:

What hazardous wastes<sup><2></sup>, <sup><3></sup>, <sup><4></sup> and hazardous constituents<sup><5></sup> have industrial operations at the Site released to on-Site soil, surface water, or ground water?

What released hazardous wastes and hazardous constituents have migrated—or will migrate—off-Site in the surface water or ground water?

### **1.1 Identification of Expert**

This report was prepared by Gary R. Chirlin, Ph.D., P.E., principal of Chirlin & Associates, Inc. His resume, testimony provided by Dr. Chirlin as an expert witness during the previous four years or more, publications from the last ten years, and compensation for this project are listed in Appendices A, B, C and D, respectively.

### **1.2 Information Relied Upon for Factual Background**

Documents and other sources of information reviewed in preparation of this report are cited in the text and listed in the Reference section of this report. In addition I relied on information obtained during a Site visit made on May 20-21, 2003. I reserve the right to supplement and revise my opinions based on any information obtained subsequent to preparation of this report.

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## **2.0 NATURAL SETTING**

The AK Steel Middletown Works is in southwestern Ohio, Butler County, south of the city of Middletown, at 39°30'N latitude, 84°22'30" W longitude. The plant boundaries are shown in Figure 2-1. Most of the plant is surrounded by residential properties: single and multiple-family homes are within ¼ mile of the Coke Plant security fence. Downtown Middletown is approximately ½ to 1 mile from the AK Steel Main Gate. Some farming occurs adjacent to the south boundary of AK Steel's slag processing/landfill area.

AK Steel is located within the Till Plains section of the Central Lowland physiographic province. The area is characterized by wide, flat valleys bordered by well-dissected bedrock uplands 100 to 300 feet above the valley floor. The wide, flat valleys actually are deep (some are steep-walled) bedrock valleys filled in with sediments. AK Steel sits atop the junction of two buried valleys—the ancestral Great Miami River valley and its tributary ancestral Todds Fork River valley. The modern Great Miami River flows along the western edge of its ancestral valley. The major modern drainage feature of ancestral Todds Fork valley is Dick's Creek.

The study area experiences a humid temperate climate, with an average of 36-40 inches per year of precipitation evenly distributed over the year, average seasonal snowfall of 17 inches, and a one year 24-hour rainfall of approximately 2.5 inches. The annual average temperature is 54°F and monthly average temperature ranges from 27°F in February to 74°F in July.

(Geraghty & Miller ["G&M"] May89 pp. 7-8; PRC 11Dec92 Sect. 3.1, 3.6).

### **2.1 Surface Water Hydrology**

Natural surface-water bodies near to AK Steel include Great Miami River, its tributary Dick's Creek, and three tributaries to Dick's Creek: North Branch Dick's Creek, Monroe Ditch, and Shaker Creek (not discussed). AK Steel is protected from flooding of the Great Miami River by several dikes located about one mile from the plant.

**Dick's Creek.** Dick's Creek passes through a corridor of non-AK Steel land which lies between the main plant (north of Oxford State Rd) and the Slag Processing Area. The creek flows east to west near the southern edge of this corridor approximately 100 ft north of the Slag Processing Area. Dick's Creek was channelized by the US Army Corps of Engineers in 1966; the area of then future landfill SWMU 38<sup><6></sup> was used as a staging area (Arcadis 16Mar01 pg. 6; Arcadis 08Feb02 pg. 5). Portions of the Slag Processing Area appear to lie within the 100-year flood zone of Dick's Creek (PRC 11Dec92 pg. 15).

Additional information is available for the reach of Dick's Creek north of the Olympic Mill Services ("OMS") Area (Arcadis 08Feb02 pp. 2). At least there, the riparian corridor was eliminated entirely during channelization. The channelized creek is approximately 30 ft wide. The floodplain, approximately 180 ft wide, has filled with fluvial sediments since 1966, and grass, shrubs and small trees now occur there. A storm of 1 inch in 24 hours typically induces flooding of Dick's Creek upstream of a railroad trestle which is 50 ft west of the Creek confluence

## **Contaminants Released to Surface Water and Ground Water at AK Steel**

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with Monroe Ditch. (Arcadis 08Feb02 pg. 5).

**Monroe Ditch.** Monroe Ditch is a south to north-flowing stream in the western portion of the Slag Processing Area. The Ditch channel typically is approximately 10 ft wide and cuts 10 or more feet below grade, and runoff water typically is 3 to 6 inches deep (Arcadis 08Feb02 pg. 2). Apparently Monroe Ditch usually or always contains water (e.g., Arcadis 08Feb02 Figs. 29, 30). (Therefore the water body would be more appropriately named a creek than a ditch). In December 1997—prior to installation of a seepage interception trench—the stream was observed to have a depth of 1 ft, a width of 3 ft, and a flow of 300 gpm. At that time approximately 50 gpm of flow was entering the Ditch via seepage along a segment labeled “seep area” on Arcadis maps. (Arcadis 15Jul99 Sect. 3.11). The channel of Monroe Ditch also has been shifted in the vicinity of its north-to-west turn. Between April 1, 1973 and April 1, 1976 the “corner was cut” off the original 90 degree turn, creating two 45-degree turns; this is evident by comparing Arcadis (08Feb02) Figs. A-7 and A-8.

**North Branch Dick's Creek.** North Branch Dick's Creek runs north to south just outside of the eastern boundary of the AK Steel South Plant. North Branch was rechanneled some “recent” time prior to 1989 (G&M May89 pg. 50). I suspect that the channel was moved approximately 450 ft east to where it now flows along the eastern boundary of the plant, notwithstanding a reference to the contrary.<7>

The streams are further discussed in Sections 3.2.5 and 3.2.6.

### **2.2 Geology**

AK Steel is situated in an area of relatively complex geology. From deep to shallow one encounters bedrock, sedimentary deposits, and fill and/or topsoil.

The bedrock materials in the study area are Ordovician age shales and limestones. The rocks are relatively flat lying and were uplifted and eroded to form a nearly flat plain termed a “peneplain”. This peneplain is dissected by ancestral drainages including the ancestral Great Miami River and Todds Fork River, both of which once flowed northward.

The bedrock surface functions as a basin for the principal water-bearing sedimentary deposits in the area (see Section 2.3); therefore the topography of the bedrock surface is of particular interest. AK Steel overlies the intersection of the Great Miami River' and Todds Fork River's buried, v-shaped river valleys (Figure 2-2). The topography of the local bedrock surface is shown in Figure 2-3. This figure also reveals the buried valleys of two tributaries to ancestral Todds Fork River; these features, too, are located beneath AK Steel. All of these ancestral river valleys are filled with glacial outwash, till<8> and other sediments deposited during the Illinoian and Wisconsin periods of glaciation. The geologic histories of the valley systems differ, and as a result the valleys contain substantially different sediment profiles. The ancestral Great Miami River valley is characterized by a predominance of sand and gravel, with lesser amounts of till. The ancestral Todds Fork River valley and its tributaries contains finer materials, predominantly sand, silty clay, till, and silty sand and gravel, and lesser amounts of clean sand and gravel. The broad contact zone between the two buried valleys is especially

## **Contaminants Released to Surface Water and Ground Water at AK Steel**

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stratigraphically complex (G&M 06Nov92 pg. 3).

The ancestral Great Miami River valley lies below part of the North Plant, the northwest portion of the Melt Area, and the eastern portion of the Coil Paint Area (Figure 2-2). Here the bedrock is eroded deeply and the buried valley may be up to 260 ft thick. Sand and gravel predominate. In most areas there are two intervening glacial tills: surficial till which consist primarily of silty clay, and lower till which is primarily clay and gravel. The lower till may occur as more than one layer with intervening sand and gravel. Consistency is not the rule: for instance, the "upper" till is absent beneath the Coil Paint Area and also is absent or replaced by fill within much of the North Plant, and the tills seem (from driller's logs) to be discontinuous along the western boundary of the plant (G&M May89 pg. 57, Figs. 24, 25, 26, 30).<sup><9></sup>

The ancestral Todds Fork River valley and its tributaries lie beneath the southeast half of the Melt Area, all of the South Plant, and most of the Slag Processing Area (Figure 2-3). Sedimentary structure is very complex within ancestral Todds Fork River valley and its tributaries. Typically, sand and gravel occur at depth, and sands, lacustrine (lake-deposited) silty clays, and till are found nearer the surface. The buried valley of the former north-flowing tributary beneath the Slag Processing Area and Melt Area contains predominantly till with lesser amounts of silty clay, sand, silty sand and gravel and sand. The buried valley of the former south-flowing tributary beneath the South Plant Area generally contains sand and gravel at depth, thick overlying till, and a shallow layer of finer sands sandwiched between layers of silty clay.

(G&M May89 pp. 2, 45-59).

The surficial geology of the Slag Processing Area has been altered by industrial activities. Soil fill and waste slag has been deposited by AK Steel or its contractors over nearly the entire land surface of the Slag Processing Area east of Monroe Ditch.<sup><10></sup>, <sup><11></sup> Investigatory geologic borings have characterized the extent of this slag fill, which ranges in observed thickness from one foot (western end of the Former Oil Separator Ponds area) to 22 feet (Mill Scale Area 3). The slag fill contains sand- and gravel-sized particles as well as boulders. (Arcadis 16Mar01 pg. 27, Figs. 15-20; App. E; Arcadis 15Jul99 pg. 26).

Based on borings completed through early 2001 within the Slag Processing Area, the glacial sediments beneath the slag fill are, in descending order, a "native silt and clay layer", a "sand and gravel layer", a "lower native silt and clay layer", and a "native layer" (Arcadis 16Mar01 Sect. 3.2). The upper "native silt and clay" unit, typically composed of 60% to 80% clay, 10% to 30% silt and fine sand, and 10% to 30% gravel, formed the land surface prior to AK Steel's waste management activities (Arcadis 16Mar01 pg. 27).

### **2.3 Hydrogeology**

The buried valleys of the ancestral Great Miami and Todds Fork Rivers contain high-yielding aquifers. Ground-water flow in this area proceeds broadly from southeast to northwest toward the Great Miami River, with local departures into municipal and industrial production wells. AK Steel has installed a number of

## Contaminants Released to Surface Water and Ground Water at AK Steel

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production wells that are screened below the lower tills in coarse sand and gravel deposits termed the lower aquifer. This supply well network yields several million gallons per day ("MGD") and supplies much of the industrial needs of the plant. Most of the water is obtained from wells located within the North Plant. As of 1987-89 the lower aquifer provided three to five MGD of which the North Plant area contributed two to four MGD. As of 1992 approximately seven MGD was being withdrawn from the lower aquifer. (G&M May89 pp. 3, 8; G&M 06Nov98 pg. 3). As of the first quarter of 2001, 8.8 MGD was being withdrawn (Arcadis 05Sep01).

### 2.3.1 Site-wide Hydrogeologic Model

During 1987-89 AK Steel contractor Geraghty & Miller, Inc. conducted a study which examined ground-water flow at the scale of the entire Middletown Works (G&M May89). The investigation installed 57 seven wells (46 "shallow" and 11 "deep" wells), drew geological cross-sections, formulated a conceptual model of the hydrogeology, created a computer model of ground-water flow for the buried valleys underlying and neighboring the facility, and simulated ground-water flow under various AK Steel pumping scenarios. The study sought a pumping configuration and schedule which would capture and withdraw all ground water passing beneath the AK Steel property.

One of the first tasks in hydrogeologic analysis is to form correlations between observed *geologic* units (e.g., sand, clay) and effective *hydrostratigraphic* (or hydrogeologic) units (e.g., aquifer, aquitard<sup><12></sup>). These correlations generally depend on the spatial scales of interest and the resolution of available data. For instance, several geologic units may be grouped together as a single aquifer, or conversely several aquifers and aquitards may be differentiated within a single geologic unit. G&M (May89) conceptualizes the hydrogeologic setting beneath AK Steel as three horizontal aquifers separated by two leaky aquitard units and subtended by a bedrock aquiclude. In this conceptual model no significant flow occurs to or from the till-mantled bedrock. The sedimentary aquifers are termed the upper, intermediate, and lower aquifers. More recently a superficial fourth aquifer—a perched aquifer within landfilled slag—has been recognized. Not all of these aquifers exist at every location. The following individual aquifer descriptions are taken from G&M (May89), with modifications reflecting subsequent investigations.

**Upper Aquifer.** The upper aquifer beneath AK Steel generally corresponds to the predominantly fine to medium sand unit beginning at depths of 5 to 30 ft below ground surface ("bgs") with typical thickness of 5 to 10 ft. Arcadis places the unit within the elevation interval 620 to 652 ft above mean seal level ("msl"). As noted in Section 2.2, onsite this hydrostratigraphic unit occurs in only the South Plant, Slag Processing Area, and portions of the Melt Area. More recent spill-related investigations have characterized the upper aquifer in the southwest corner of the Melt Area as sand and gravel, well sorted sand, and silty sand and gravel. Within the Slag Processing Area the upper aquifer discharges through fluvial sediments to Monroe Ditch on the west<sup><13></sup> and through fluvial sediments to Dick's Creek on the north. Upper aquifer flow manifests as seeps along Dick's Creek between MDA-29S and MDA-28S and—observed subsequent to the 1998 installation of the Monroe Ditch interception trench—intermittently as seeps at the southwest (near MDA-09) and northwest (near MDA-36S) corners of the OMS Area. In the vicinity

## ***Contaminants Released to Surface Water and Ground Water at AK Steel***

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of the Monroe Ditch interception trench, downward leakage from the perched aquifer through the native silt and clay to the upper aquifer is indicated by elevated pH. Figure 2-4 shows Arcadis' interpretation of the extent of the Upper Aquifer and interpolated potentiometric surface as of April 2001. (G&M May89 pp. 51, 77; G&M 06Nov92 pp. 12-13; OEPA 01Dec99 Att. 4c Fig. 2; Arcadis 08Feb02 Sects. 4.5.1, 4.5.2, 9.1, 9.5.2).

Within much of the plant area the intermediate aquifer is the uppermost permeable unit. It corresponds to sand and gravel beds at depths ranging from near surface to 55 ft bgs (but silty sand to sand in the Melt Area). Typically, in the intermediate aquifer ground water is encountered 50 to 60 ft bgs, and saturated thickness is 10 to 20 ft (but only 2 to 4 ft thick in the Melt Area). The intermediate aquifer base, where it contacts till, ranges from 50 to 75 ft bgs. However, in some places this till may be absent and the intermediate aquifer merge unhindered with the lower aquifer (e.g., at well GM-41 [G&M May89 pp. 51-52]). The intermediate aquifer is unconfined in some areas and confined (e.g., by the upper till with overlying upper aquifer) in others. Figure 2-5 shows Arcadis' interpretation of the extent of the Intermediate Aquifer and interpolated potentiometric surface as of April 2001. (G&M May89 pp. 51-52).

The lower aquifer is the prolific coarse sand and gravel unit which is tapped by all of the AK Steel production wells. The top of this aquifer is 120 to 150 ft bgs (75 to 90 ft bgs in South Plant, which is underlain by the relatively shallow former south-flowing tributary to ancestral Todds Fork River). Typical thickness is 80 to 100 ft (30 to 60 ft in South Plant). The lower aquifer consistently is underlain by till or blue clay mantling the bedrock. The horizontal velocity of ground water in the lower aquifer is on the order of 0.5 feet per day ("ft/d"), or about 180 feet per year (G&M May89 pg. 69). Due to shallow bedrock the lower aquifer is absent from portions of the Slag Processing Area and the southwest corner of the Melt Area. Figure 2-6 shows Arcadis' interpretation of the extent of the Lower Aquifer and interpolated potentiometric surface as of April 2001. (G&M May89 pp. 53-54; OEPA 01Dec99 Att. 4c Fig. 3).

No sedimentary aquifer units are present where bedrock outcrops locally in the south-central Slag Processing Area (G&M May89 Figs. 21, 30).

### **2.3.2 Slag Processing Area Perched Unit**

The hydrogeology of the Slag Processing Area has received special attention due to an Ohio Dept. of Environmental Protection Agency ("OEPA") October-November 1997 discovery of polychlorinated biphenyls ("PCBs") in ground water seeps draining to Monroe Ditch. The hydrogeologic setting is described in this section, and the PCB releases are discussed in Section 3.2.5.

The slag and other fill deposited in the Slag Processing Area have created a new, uppermost, manmade hydrostratigraphic unit. This saturated unit lies above the upper aquifer described by G&M (May89) and was not discovered until 1998 during construction of the Monroe Ditch interception trench (Arcadis 15Jul99 Sect. 2.2). As mentioned at the end of Section 2.2, prior to slag and landfill deposition the surficial geologic material in the Slag Processing Area (beneath top soil) was silt and clay. These materials have relatively low permeability and therefore impede downward flow of infiltrating water. Slag deposited on top of the native silt and clay is quite permeable to ground-water flow (field testing of

## **Contaminants Released to Surface Water and Ground Water at AK Steel**

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Arcadis 16Mar01 Sect. 4.7). Rainfall and industrial discharges of water to the surface infiltrate the slag fill, accumulate on the surface of the silt and clay, saturate the fill, and flow laterally along the top of the native silt and clay. Therefore the slag contains significant water-yielding zones (Arcadis 15Jul99 pg. 26; Arcadis 16Mar01 pg. 27). Water is encountered near the contact with the native silt and clay approximately 6 to 17 feet bgs (Arcadis 16Mar01 Sect. 3.3.1). The type of setting where an aquitard suspends flow above a lower unsaturated zone is known as perched flow. Arcadis therefore refers to the silt and clay as a "perching unit" and the slag and other fill as the "perched groundwater zone" (Arcadis 16Mar01 pg. 27).<14>

Perched water within the slag has been encountered only in the area bounded by wells MDA-01P, MDA-22P, MDA-25P, and MDA-09P.<15> (Well locations are shown in Figure 3-8). It has not been found in other investigated areas including Mill Scale Area 1; the southeast portion of the Slag Processing Area encompassing the Former Oil Separator Ponds, Compressor Building, Oil Storage Area, and Air Dump; and the Raw Slag and B-Scrap Areas. (Arcadis 16Mar01 Sects. 3.3.1, 3.4.1, Fig. 6).<16> In general, the perched ground-water surface is influenced by the underlying top-of-clay topography (Arcadis 08Feb02 pg. 57).<17> Between MDA19P and MDA24P in south-central OMS Area the perched water level is persistently high, echoing an underlying ridge in top-of-clay elevation. From this "high" area ground-water flow diverges semi-radially towards the north through west to south. (Arcadis 08Feb02 pp. 57, 60, Figs. 16-19). Saturated thickness of the perched unit thins south to north from a maximum of approximately 5-6 ft (Arcadis 08Feb02 Fig. 20).

Arcadis explains the absence of perched ground water in north-central OMS Area as follows. North of well MDA22P (at the pad-mounted transformer) the native clay thins and becomes sandier and thus more permeable. Infiltration does not accumulate to saturation on the clay and continues downward to the upper aquifer. No borings northwest to northeast of MDA22P have encountered a saturated perched unit. (Arcadis 08Feb02 pp. 55, 60, 62, 93). Arcadis (08Feb02 Sect. 9.5.1) offers three lines of supporting evidence that downward leakage has occurred and has prevented formation of a perched unit. They are: increased sand and gravel content and thinning of the unit, occurrence of elevated pH (conveyed in leachate from surficial slag) in the upper aquifer where the perched unit is absent, and occurrence of PCBs (from surface releases) in the upper aquifer near Dick's Creek and at the interception trench.

Precipitation provides the natural source of water which recharges the perched unit. Precipitation has been augmented by industrial discharges of water to the land surface within the OMS Area. Currently water for most of these industrial activities is pumped from a water reservoir in the Pump House located in north-central OMS Area; its sources in turn include diverted NPDES Outfall 002 effluent and Monroe Ditch interception trench treatment system effluent.<18> In the past AK Steel's steel slag quenching and kish pot dust control waters were discharged along the northern edge of a dumping platform east of Mill Scale Area 2 and north of the Compressor Building (Arcadis 16Mar01 pg. 30, Fig. 2).<19> This location is referred to as the "kish pot area". These discharges at the kish pot area began in April 1997 and ended in April 2000 (Arcadis 16Mar01 pg. 30) or

## **Contaminants Released to Surface Water and Ground Water at AK Steel**

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about January 2000 (USEPA 17Aug00 para. 19). A December 1999 AK Steel water balance states that 110,000 gpd was used for slag quenching and 75,000 gpd for kish pot watering. Additional water discharges within the Slag Processing Area as of the December 1999 water balance included 50,000 gpd for road dust suppression and 20,000 gpd for screening station dust suppression. (Arcadis 15Jul99 pg. 27; Frost & Jacobs 03Dec99 para. 10; Arcadis 16Mar01 pg. 30, Fig. 2; Arcadis 08Feb02 pg. 7).

The former slag quenching and kish pot watering discharges are of uncertain significance to past behavior of the perched aquifer system. Arcadis previously concluded that a "major [ground-]water mound [in the perched unit] centered around the steel slag and kish pot area is due to the continuous kish pot water process" (Arcadis 15Jul99 pg. 27), that "local water flow in the perched zone has been heavily influence by [this] recharge" (Arcadis 15Jul99 pg. 32), that the "quenching process is an important source of recharge to the perched zone , and a hydraulic driver of the seeps in Monroe Ditch" (Arcadis 15Jul99 pg. 27), and that the water level "high" observed in Fall 2000 between the kish pot area and the Compressor Building also may be a remnant effect of the kish pot quenching discharge (Arcadis 16Mar01 pg. 30, Fig. 2). However, the water level high has persisted through the December 2001 synoptic water level survey (Arcadis 08Feb02 Fig. 19) even though the slag is quite permeable. I infer that the water level high and consequent seepage to Monroe Ditch are not explained by past discharges but are persistent features of a precipitation-driven perched system. Indeed, Arcadis seems to have abandoned its earlier theory. Arcadis (08Feb02 Sect. 9.3) does not mention the former industrial discharges and in particular does not attribute Monroe Ditch seepage, and associated PCBs migration, to them.

Monroe Ditch existed as a natural drainage feature prior to slag deposition (Arcadis 16Mar01 pg. 10). Slag deposits currently extend down to the east bank of the Ditch and the base of the slag is several feet above the base of the Ditch (Arcadis 15Jul99 Fig. 12; Arcadis 16Mar01 Fig. 16; Arcadis 08Feb02 pg. 57). It is expected that on the east side of the Ditch seeps from the perched unit emerge approximately at the base of the water-bearing slag where the surface of the native silt and clay outcrops along the Ditch channel (e.g., Arcadis 15Jul99 Fig. 12). An interception trench has been installed and upgraded (in January 1999) by Arcadis for AK Steel. This trench reportedly now captures all of the subsurface flow that formerly generated seeps on the east bank of Monroe Ditch, except at the south end of the OMS Area (Arcadis 16Mar01 Sect. 2.2.2; Arcadis 08Feb02 Sect. 9.5.1).

As noted above, the perched aquifer is of limited extent. For instance, there is no slag deposited on the west side of the Monroe Ditch; hence there is no perched aquifer there. (USEPA Aug00 Exh. 5; PRC 11Dec92 Sect. 4.5.2). Slag is deposited along the south shore of Dick's Creek, but no saturated zone occurs within the slag there (Arcadis 16Mar01 Figs. 15, 19, 20).

### **2.3.3 Vertical Ground-water Flow**

Vertical flow—especially downward flow—between aquifers at the Site is of interest for predicting fate and transport of spilled materials. G&M (May89) states that the three main aquifers are in limited intercommunication due to typically continuous till units separating them (G&M May89 pg. 77). Nevertheless G&M

## **Contaminants Released to Surface Water and Ground Water at AK Steel**

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concludes that interaquifer leakage does occur either across the aquitards or where they pinch out. Hydraulic interconnectivity between the intermediate and lower aquifers was demonstrated by oscillatory airflow in a nearly dry intermediate aquifer piezometer (GM-12S) responding to pump cycling of lower aquifer wells (G&M May89 pp. 26, 59-61, 77-78). Hydraulic interconnectivity also is inferred from the appearance of intermediate aquifer cones of piezometric depression above lower aquifer pumping wells.

In fact, the direction of the vertical component of ground-water flow (up or down) varies across AK Steel. Of course the lower aquifer extraction wells induce a potential for downward flow from nearby portions of the intermediate aquifer. However, under less than vigorous pumping, flow is inferred to be upward in some areas (G&M May89 Figs. 33, 36). Potential flow between the upper and intermediate aquifers generally is downward (G&M May89 Figs. 21, 23, 30, Table 6), although the magnitude of such flow may be limited by intervening aquitards.

AK Steel's interest in interaquifer flow is a component of its effort to design a Site-wide ground-water containment pumping scheme. If such a system is successful, then any spill to ground water contaminates the aquifers beneath a portion of the AK Steel property but does not escape offsite. To this end G&M (May89) first determined that "in most situations the [pre-1989] pumping patterns used are believed to be insufficient to contain ground water onsite in the North Plant" (G&M May89 pg. 4).

G&M (May89) then designed a containment system which relies on pumpage from the lower aquifer supply wells to draw in ground water from all three aquifers. <20> In its computerized model of the Site's buried valley ground-water system, G&M (May89) assigned nonzero leakance coefficients to enable vertical cross-aquard flow. The G&M simulations concluded that—under certain proposed pumping schemes using existing lower aquifer wells totaling 3.5 MGD—water particles would indeed migrate from the water table across the intervening aquitards and down to the pumping wells. This implied that full Site containment of all three aquifers would be established. (G&M May89 pp. 67, 70-73, Figs. 39-42).

However, subsequent field investigations have indicated that, contrary to these modeling results, "Armco production well pumping does not control [i.e., capture] upper aquifer ground-water flow direction" (G&M 06Nov92, pg. 3), and "it appears AK's on-site deep production well pumping system does not influence ground water flow in the shallow aquifer in the southern half of the AK site. Ground water flow is instead influenced by or flows to Dick's Creek" (OAG 29Jan98 pg. 4).

Moreover, subsequent modeling revisions and water level data apparently imply that containment of the intermediate and lower aquifers requires increasing the production rate to seven MGD; that step reportedly was taken in 1992 (G&M 06Nov92, pg. 3). <21> Even so, more recent piezometric data does not necessarily demonstrate capture of the intermediate aquifer. For instance, the direction of intermediate aquifer ground-water flow in the Coil Paint Area is ambiguous; in particular it is not clear whether the flow is captured by lower aquifer extraction wells or continues offsite to the north (OEPA 01Dec99 Att. 4c Fig. 2; Arcadis 05Sep01 Fig. 2).

***Contaminants Released to Surface Water and Ground Water at AK Steel***

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Recent field investigations within the Slag Processing Area have indicated that the vertical component of flow is consistently and uniformly downward from the perched aquifer to the upper aquifer. (Arcadis 08Feb02 pg. 62).

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### **3.0 POTENTIAL OR ACTUAL SOURCES**

Releases of hazardous materials or hazardous constituents can be determined from historical records of spills, disposal activities, and certain operational practices, and can be inferred from environmental sampling. Both approaches have been taken in this report. Section 3.1 briefly describes the five main areas of the AK Steel plant facility. For each of the five areas, Section 3.2 discusses evidence of potential or actual releases of hazardous wastes or hazardous constituents to the environment based on both historical records and environmental sampling.

#### **3.1 Facility Description**

This section provides an overview of steel production and a description of selected portions of the AK Steel plant. Emphasis is placed on facilities and processes which generate, handle or store hazardous wastes. Because releases may have occurred due to past operations, and because some former wastes are deposited in Site landfills, I also have included available information on past AK Steel waste management practices. I describe certain typical industry practices to help fill out the picture where Site information is limited. Site specific information is taken from PRC (11Dec92 Sect. 2) and USEPA (Aug97 pp. 1, 5-12) unless otherwise cited. Background and typical industry practices are drawn from USEPA (Sep95a Sect. III.A.1, Sect. IIIB), USEPA (Dec95), USEPA (Apr02 Sect. 5), 40 CFR §261.32, and American Iron and Steel Institute (May 2003).

AK Steel is a fully-integrated steel manufacturing facility, which is to say that it produces finished steel from the principal raw materials coal, iron ore, and scrap steel. Main stages of steel production occur in the coke ovens, blast furnaces, steel furnaces, and rolling and finishing mills. Figure 3-1 provides a process overview diagram for a generic iron and steel plant, and Figure 3-2 does likewise for the Middletown Works.

The AK Steel plant has been in operation since 1910. At the time of a USEPA June 1996 inspection the mill occupied 2791 acres (approximately 4.3 square miles) and consisted of five manufacturing areas (Figure 3-3). They are the Melt Area, South Plant Area, North Plant Area, Coil Paint Area, and Slag Processing Area. The Coil Paint Area has since been sold to Materials Science Engineering, excepting a parcel containing the site of three former wastewater lagoons (SWMU 23). (PRC 11Dec92 pp. 7-11; USEPA Aug97 pg. 1; OEPA 01Dec99 pg. 2).

##### **3.1.1 The Melt Area**

The AK Steel Melt Area produces steel slabs. The Melt Area includes a by-product coke plant, sinter plant, blast furnace, two basic oxygen furnaces (the BOF Shop), controlled argon stirring-oxygen blowing facility, vacuum degasser, continuous casting facility, three wastewater treatment facilities (a fourth previously received OHF wastewaters), and large stockpiles of coal, scrap metal and other raw materials and slags. The former open hearth furnaces ("OHF") also were located in the Melt Plant area. The open hearth furnaces were closed in 1985 (PRC 11Dec92 pg. 48).

Several hazardous wastes and hazardous constituents are created and/or

## **Contaminants Released to Surface Water and Ground Water at AK Steel**

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managed within the Melt Area.

### **3.1.1.1 Cokemaking**

As a precursor to steel production, coke is created from coal in coke ovens under high temperature and anoxic conditions. Figure 3-4 provides a process diagram for cokemaking in a generic steel plant. Coal is charged to an oven from above, the oven is sealed, and at the end of a 14 to 36 hr heating period hot coke is pushed from the oven into a rail car and taken to a quench tower where it is cooled with a water spray, screened, and then stored for subsequent use in ironmaking. Coke "breeze" also is generated; it consists of relatively fine coke particles which are collected in coke quench station sumps and in handling and screening of the coke. AK Steel currently has one coke battery, the Wilputte Battery, containing 76 ovens. A former second battery, the Still Coke Battery, was permanently shut down in December 1995.

As the coal is heated within the ovens, volatile matter is driven off as hot raw coke oven gas which contains—in addition to a desirable gas fuel—gaseous crude light oil (consisting mainly of benzene, toluene and xylenes), tar, naphthalene, ammonia, hydrogen sulfide, and hydrogen cyanide.<sup><22></sup> The by-product coke-making process used at AK Steel captures the raw coke gas and separates out some or all of these materials. The cleaned coke oven gas ("COG") which emerges at the end of this sequence is used as a fuel for coke oven underfiring and in the Hot Strip Mill furnaces.

In the first step of the by-product process, raw coke gas is scrubbed with an aqueous fluid—flushing liquor—to condense tar and moisture from the gas. The flushing liquor and scrubbed coke oven gas then part ways and follow separate paths through the by-product plant. Figure 3-5 provides a diagram of processes at a generic coke by-product recovery plant; some of the details differ from those currently or historically practiced at AK Steel.

At AK Steel the flushing liquor enters the "tar and liquor plant" within the by-product plant. The liquid flows into a tar decanter tank and settles into three layers: coal tar decanter sludge<sup><23></sup> at the bottom, coal tar in the middle, and aqueous flushing liquor on top.

Coal tar sludges, including from the decanter, are discussed a few paragraphs below.

Coal tar from the decanter is sent to the tar storage tank (AOC 2). Coal tar also is removed along the scrubbed coke oven gas pathway at two locations: the primary cooler and an electrostatic precipitator. Tar from the primary cooler is sent to a tar collection tank and then to the tar storage tank (AOC 2). <Is this tar stream actually coke oven gas condensate?> Tar from the electrostatic precipitator is sent directly to the tar storage tank (AOC 2). (USEPA 09Jun03).

Product tar at AK Steel has been stored in two large tanks (AOC 2) only one of which remains. A tar loading area with overhead rack for dispensing to railcar or truck is located adjacent to the remaining AOC 2 tank.

Most of the aqueous flushing liquor from the coal tar decanter tank is recycled to

## **Contaminants Released to Surface Water and Ground Water at AK Steel**

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the coke battery; however, a sidestream referred to as "excess waste ammonia liquor" is removed. Excess waste ammonia liquor is the principal process wastewater generated at coke by-product plants. Currently at AK Steel excess waste ammonia liquor is discharged via a wastewater equalization tank (SWMU 14) to the City of Middletown sewer system.

**Coal tar sludges (K087, K141, K142).** Coal tar sludge is generated at the decanter tank as mentioned above and at the tar collection tank and the tar storage tank. The coal tar decanter sludge (K087) is removed to bins; its handling has changed over time and is discussed further in the next paragraph. I have no information on the fate of the tar collection tank sludge (K141, K142; USEPA 09Jun03). <resolve fate> As of the PR/VSI the tar storage tank sludge (K141, K142; USEPA 09Jun03) periodically was removed and "recycled to the coke ovens" (PRC 11Dec92 pg. 90). The method of recycling is not described, but it may have been the same as for coal tar decanter sludge.

Between early 1983 and the present, the coal tar decanter sludge (K087) generated by coking operations has been handled three different ways at AK Steel. <24> In all three cases the sludge first is directed into coal tar decanter sludge collection bins. These bins are filled from an array of vertical discharge pipes along the coking batteries (the collections bin area) and from a drop box near the batteries (the drop box area) (PRC 11Dec92 App. A photos 31, 32, 79). The two filling areas are grouped together in the PR/VSI as SWMU 16. <It is unclear whether either of these areas services the tar collection tank as well as the decanter tank?resolve>.

Prior to February 1990 the highly viscous sludge was transported daily to a particular coal pile (SWMU 17 "Robin Hood Coal Pile") and placed onto the coal pile using a bulldozer. <25> Every two to three days the K087/coal mixture was loaded onto the conveyor belt leading to the coke batteries. (PRC 11Dec92 pp. 46, 47, App. A photos 33, 34; Cox-Colvin & Associates "CCA" 19May00 pg.2). The Robin Hood Coal Pile, along with the rest of the coal storage area, is underlain by bare soil.

In February 1990 an upgraded sludge recycling system was implemented. In this second sludge handling method the filled collection bins were hauled by hopper (PRC 11Dec92 App. A photo 29) to a coal tar decanter sludge recycling area (SWMU 15) operated by AKJ Industries. Within this bermed concrete-floored area, the sludge was transferred to a reclamation unit, mixed with fuel oil from an adjacent storage tank to reduce viscosity, and sprayed onto coal ascending the enclosed conveyor to the coking batteries. (Armco 29Jan90 pg. 5; PRC 11Dec92 pp. 44-49, App. A photos 27, 28, 30).

Finally, when one coke battery was shut down in 1995, AK Steel adopted the current method of coal tar decanter sludge handling, in which the contents of the bins are <what is the current method?>

Meanwhile, along the other major process pathway at the Coke Plant the coke oven gases, after initial flushing, undergo additional treatment described below. Cooling of the gases generates liquid wastes including tar, coke oven gas

## Contaminants Released to Surface Water and Ground Water at AK Steel

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condensate <26>, <27>, final cooler wastewater<28>, and noncontact cooling water system blowdown. Except for the tar (described above), all of these liquid wastes currently are discharged via the aforementioned wastewater equalization tank (SWMU 14) to the City of Middletown sewer system.

**Benzol Plant.** Until 1984 the coke oven gas next entered the "benzol plant" which was located near to the coke ovens. Benzol is another name for the crude light oil present in the raw coke oven gas, and as mentioned it is a mixture of benzene, toluene, xylene and other compounds. The benzol plant stripped and distilled the crude light oil to obtain benzene and other fuels. Light oil residues (K143) and related wastewater sump residues (K144) may have been generated at this step. I have not obtained site-specific information on any other units of the pre-1984 AK Steel by-product gas treatment train. Typically ammonia—whose corrosivity would damage downstream components—would have been removed by contact with sulfuric acid, producing product ammonium sulfate (commonly used in fertilizers). Lime sludge from the ammonia still (K060) may have been generated at this step. Typically naphthalene—which would otherwise foul gas lines by condensation—would have been removed by wash oil and either combined with produced tar or sold separately. Naphthalene residues (K145) may have been generated at this step. And typically hydrogen sulfide—which would otherwise violate air quality emissions governing coke gas combustion—would have been removed and converted into elemental sulfur or sulfuric acid. While the benzol plant was in operation, fuel oil products were stored at a tank farm (SWMU 20). Products were dispensed to tanker cars at the rail car transfer area (AOC 4) on the southwest side of the benzol plant; drip pads were placed between the tracks (PRC 11Dec92 App. A photo 80).

For economic reasons the benzol plant was shut down in 1984 (PRC 11Dec92 pg. 50). The benzol constituents now are retained as components of the coke gas fuel. At the time of USEPA's February 1991 visual site inspection ("VSI") the former plant site contained abandoned distillation columns, boilers, heat exchangers, pipes, etc., and the tank farm (SWMU 20). A semi-bermed area of the tank farm (not a tank) was being used to hold tar storage tank sludge (K142) from a cleanout of the AOC 2 tar storage tanks. (PRC 11Dec92 pp. 10, 50, 89-91, 148, 149). In about 1993 or 1994 the benzol plant was completely dismantled; components were removed or, in the case of secondary containment and tank carcasses, broken up and buried onsite (C. Batliner during field trip, 20May03).

The current coke oven gas treatment train continues to remove ammonia (now yielding anhydrous ammonia, perhaps by the PHOSAM process) and hydrogen sulfide (converted to sulfuric acid).

Stormwater runoff from the coal pile area of the Coke Plant drains via the Coal Pile Spray Pond (a.k.a. Emergency Spray Pond) and outfall 003 to Dick's Creek (OEPA 17Dec91 item 6; site visit 20May03).<29> The Coal Pile Spray Pond currently is dredged approximately annually; the sludge is pumped into adjacent Geotubes for dewatering, analyzed for RCRA hazardous characteristics, and then disposed of offsite (K. Hileman during field trip, 20May03).

Stormwater runoff from the Coke Plant and by-products area enters storm sewers that flow via an SPCC pond to outfall 002 and Dick's Creek (PRC 11Dec92 pg.

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### **3.1.1.2 Ironmaking**

At AK Steel metallic iron is produced within the Melt Area using a blast furnace. Figure 3-4 provides a process diagram of ironmaking in a generic steel plant. Middletown Works currently has one blast furnace, the No. 3 furnace, which has two tap holes and two cast houses. A blast furnace is a countercurrent reactor. Iron ore, hot briquetted iron, sinter (see below), coke, and limestone (or dolomite) which serves as a flux are charged to the top of the blast furnace and descend to the furnace hearth over a period of six to eight hours. Preheated air ("hot blast") is pumped through a circumferential ring of nozzles known as tuyeres just above the hearth and flows upward, undergoing several chemical reactions before the hot gases reach "uptakes" at the top of the furnace in about 6 to 8 seconds. The furnace hearth periodically is tapped, and molten iron ("pig iron", "hot metal") and liquid slag exit down a trough. The iron is directed along runners to refractory-line railcars which proceed to the steelmaking furnaces. The slag is diverted to a pit adjacent to the blast furnace, allowed to cool, and removed to the Slag Processing Area. Raw materials periodically are added to the blast furnace to maintain an approximately constant level. Once started, a blast furnace runs continuously for up to a decade except for short periods of scheduled maintenance.

Combustion of the coke in the blast furnace both provides heating energy for the furnace and creates a reducing agent—carbon monoxide—which converts iron ore to metallic iron. Heated limestone converts to lime and melts forming a fluid slag, which reacts with and captures sulfur (converting iron sulfide to calcium sulfide) and absorbs other impurities from the charge, including oxides of silicon, aluminum, magnesium and calcium.

Slag is the principal solid waste/by-product of ironmaking. According to a 1999 table of nine undated (probably November 1999) chemical analyses, the major components and approximate mass percentages of AK Steel blast furnace slag are calcium oxide (CaO, 40%), silicon dioxide (SiO<sub>2</sub>, 36%), magnesium oxide (MgO, 9%), aluminum oxide (Al<sub>2</sub>O<sub>3</sub>, 9%), iron (II) oxide (FeO, 1%), manganese oxide (MnO, 0.7%), and potassium oxide (K<sub>2</sub>O, 0.4%) (AK Steel 11Nov99). AK Steel slag has been managed and processed by subcontractors within the Slag Processing Area for use as fill and aggregate.

Combustion gases from the blast furnace are cleaned (using cyclones/multicyclones and wet scrubber), cooled, and then burned as a fuel for stoves which preheat incoming furnace air (the hot blast), and for plant boilers.

Wastewaters generated from the blast furnace operation, including from gas cooling and scrubbing, seals and drip legs, and slag pit cooling, pass through a Dorr thickener and then are recycled to the furnace for reuse. The blowdown from this circuit and wastewater from the raw-water softener clarifier and noncontact blast furnace cast house shell cooling water are discharged to the Blast Furnace/Sinter Plant Wastewater Treatment Ponds (SWMU 11). These wastewaters typically contain NPDES regulated constituents including suspended particulate matter, cyanide, phenol, and ammonia, as well as other substances (USEPA Dec95 Sect. C.2). Effluent from the ponds is sent to the blast

## **Contaminants Released to Surface Water and Ground Water at AK Steel**

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furnace/sinter plant wastewater treatment plant ("WWTP") and then discharged through internal outfall 613 to external outfall 011 (Great Miami River).

Solid wastes from the blast furnace operation, other than slag, include air pollution control ("APC") dust and sludges from gas cleaning and water cleaning. APC dusts and sludges typically contain iron, calcium, silicon, magnesium, manganese, and aluminum (USEPA Dec95 Sect. C.2). The sludge from SWMU 11 is removed periodically by soil crane and landfilled.<sup><30></sup> The solid wastes from the blast furnace other than slag are sent to onsite landfills.

Stormwater from the blast furnace area drains via outfall 003 to Dick's Creek (M. Osika, pers. comm. 05Jun03).

### **3.1.1.3 Sinter Plant**

The sintering facility fuses iron-bearing particulate matter from various plant wastes and byproducts with limestone and finely divided fuel (such as coke breeze) into sinter agglomerates that can be reintroduced into the blast furnace. AK Steel uses coke breeze, sinter ore, mill scale, taconite pellet fines and sinter fines as input materials.

Dusts collected by sinter plant air pollution control devices either are reintroduced as a raw material into the sinter plant or are landfilled onsite. Air pollution control scrubber wastewater is discharged to the Blast Furnace/Sinter Plant Wastewater Treatment Ponds (SWMU 11). Effluent from the ponds is sent to the Blast Furnace/Sinter Plant WWTP and then discharged through internal outfall 613 to external outfall 011 (Great Miami River). Sludges from the WWTP are landfilled onsite. Used oil from maintenance at the Sinter Plant was stored in drums (SWMU 21).

Stormwater runoff from the sinter plant area ultimately discharges through outfall 003 to Dick's Creek.

(PRC 11Dec92 Sect. 2.2.2; USEPA Aug97 pp. 1, 6-7).

### **3.1.1.4 Steelmaking**

Steel furnaces produce steel from molten iron, cold scrap steel, alloy materials, and lime, fluorspar and/or other fluxes. Figure 3-6 provides a process diagram for steelmaking at a generic steel plant. In the past open-hearth furnaces ("OHF") were used; the OHF at AK Steel have been replaced by basic oxygen furnaces ("BOF").

Prior to introduction into the steel furnaces, the molten iron from the blast furnaces is poured into a transfer ladle. At a desulfurization station lime and manganese are blown into the hot metal in the ladle through a lance. An ensuing reaction converts sulfur to magnesium sulfide which floats to the surface as a slag and is skimmed off.

The molten iron and other raw materials then are introduced into one of the two basic oxygen furnaces, #15 and #16, at the AK Steel BOF Shop. High purity oxygen is injected into the BOF at supersonic velocity. Over a 30 to 45-minute period the oxygen oxidizes carbon and silicon in the iron and other impurities

## **Contaminants Released to Surface Water and Ground Water at AK Steel**

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(mainly phosphorus and sulfur) and these oxidized substances partition into the slag. The remaining charge is molten steel, to which alloys may be added. The steel is poured into transportable ladles. At AK Steel the steel may be further refined in the controlled argon stirring-oxygen blowing facility and the vacuum degassing facility. Then the steel is poured into a reservoir (tundish) supplying the single twin-slab Continuous Caster which produces steel slab. The slab is cut into lengths with an automatic torch cutting system and is transferred to the Hot Strip Mill located in the South Plant Area.

BOF wastewater is generated from the gas cooling and cleaning system (scrubber) and from noncontact cooling water. These fluids are sent to the BOF Wastewater Treatment Facility (SWMU 13), treated, and in large part recycled to the BOF. Blowdown is discharged via internal outfall 631 and external outfall 003 to Dick's Creek.

Wastewater generated from steam condensation within the vacuum degasser is sent to the Hot Strip Mill WWTP, where it is treated and then discharged via internal outfall 005 and external outfall 015 to Dick's Creek.

Solid wastes from the BOF include steel-making slag, carbon precipitated as graphite and known as kish, APC dust and sludge, and BOF WWTP sludge. Steel-making slag at AK Steel, as characterized by analyses of slag from about 20 heats from each of the two furnaces on November 11, 1999, is composed primarily of oxides of calcium (CaO), iron (FeO), silicon (SiO<sub>2</sub>), magnesium (MgO), manganese (MnO), and aluminum (Al<sub>2</sub>O<sub>3</sub>), significant metallic iron (Fe), and relatively small amounts of phosphorus (P) and sulfur (S).<sup><31></sup> The steel slag is transported to the Slag Processing Area where it is processed for recycling or sale. The BOF APC dusts from desulfurization and deslagging are shipped offsite for disposal as nonhazardous waste. BOF air pollution control dust/sludge typically consists mostly of iron, with smaller amounts of silicon, calcium, and other metals (USEPA Dec95 Sect. C.2). The BOF WWTP sludge is landfilled onsite; previous sampling of the sludge by Armco showed the presence of iron oxide only, and the material was determined to be nonhazardous (PRC 11Dec92 pg. 41).

Solid wastes from the controlled argon stirring-oxygen blowing facility and vacuum degasser include APC dusts which are classified as nonhazardous and are shipped offsite, and a share of the Hot Strip Mill WWTP sludge which is disposed of onsite.

Stormwater from the BOF area ultimately drains via outfall 003 to Dick's Creek (USEPA Aug97 pg. 14).

### **3.1.2 South Plant Area**

The AK Steel South Plant Area forms (reshapes) steel from steel slab, conditions the steel, and applies certain finishes to the steel surface. The South Plant Area currently includes a Hot Strip Mill, two Pickling Lines, a Cold Rolling Mill (a.k.a. Cold Strip Mill, "CSM"), batch annealing furnaces, temper mills<sup><32></sup>, continuous annealing hot dip aluminized line, electrogalvanizing line, and three wastewater treatment facilities.

The South Plant Area also contains a Solid Waste Transfer Area (SWMU 37) at which solid wastes including railroad ties, contaminated soil from spills and

## Contaminants Released to Surface Water and Ground Water at AK Steel

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excavations, and refuse formerly were accumulated prior to offsite disposal. In the past the South Plant Area contained the slag processing area and a concrete plant.

### 3.1.2.1 Steel Forming

At AK Steel the slab steel is formed into strip using a series of hot- and cold-rolling operations. Certain surface cleaning steps are involved. Solid and liquid wastes are generated during these processes. Figure 3-7 provides a process diagram of forming and finishing operations in a generic steel mill. The slabs/hot strip mills path of that diagram applies to current operations at AK Steel.

**Hot Strip Mill.** Steel slab from the continuous caster proceeds to the Hot Strip Mill located within the South Plant Area. At the Hot Strip Mill slabs are rolled into flat sheet steel less than 1/2 inch thick. During the hot-rolling process a mix of oxides known as mill scale forms on the surface of steel. The mill scale is removed by a high-pressure water wash. Lubricants which are used during hot-rolling coat the mill scale.

The Hot Strip Mill WWTP (SWMU 32), <33> built in 1968-1969, treats and recycles water from the Hot Strip Mill (also including the hot slab mill), the continuous caster, and the vacuum degasser. Blowdown from the Hot Strip Mill WWTP is discharged via internal outfall 005 and external outfall 015 to Dick's Creek. Wastewater sludge from the Hot Strip Mill WWTP is disposed of at onsite landfills. Mill scale is processed to remove some of the coating of lubricating oil and then hauled to the Slag Processing Area for metals reclamation.

Stormwater runoff from the Hot Strip Mill vicinity discharges via an SPCC pond and outfall 015 to Dick's Creek.

**Pickling Lines.** Hot-rolled strip may proceed to the pickling lines where oxides and scale are chemically removed from the steel surface. Acid pickling at AK Steel uses two pickling lines, the No. 4 and No. 5 Pickle Lines. The steel passes through a hydrochloric acid bath and a series of water wash tanks. Scrubbers control acid fumes from the tanks.

The pickling lines generate spent pickle liquor ("SPL" [K062]) and other wastewater. SPL is accumulated at the SPL Tank Farm (SWMU 33), filtered, and the bulk is injected underground via two wells in the South Plant. <34>.

Stormwater from the pickling lines vicinity discharges via outfall 004 to North Branch Dick's Creek.

Pickling rinsewaters and scrubber wastewater from the two pickling lines are sent to the South Terminal WWTP (SWMU 28). This plant also receives cold mill cooling/rinse water, rinsewaters from the aluminum coating line, and EGL cleaning and pickling rinsewaters and scrubber wastewater (discussed below). Effluent from the South Terminal WWTP is discharged via the South Terminal Wastewater Treatment Polishing Ponds (SWMU 29), internal outfall 641, and external outfall 004 to North Branch Dick's Creek.

Sludge from the South Terminal WWTP is landfilled onsite. USEPA (Sep95a)

## **Contaminants Released to Surface Water and Ground Water at AK Steel**

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indicates that sludge from the types of wastewaters sent to the South Terminal may exceed RCRA toxicity characteristic limits (see below). A sample of South Terminal WWTP sludge passed the EP Toxicity test in (apparently) 1983 (PRC 11Dec92 pp. 64, 66).

Stormwater from the South Terminal WWTP vicinity discharges via outfall 004 to North Branch Dick's Creek.

**Cold Rolling Mill.** AK Steel has one cold-rolling mill, the No. 3 mill. The five-stand mill reduces steel strip thickness, imparts a smooth dense surface, and develops controlled mechanical properties of the product.

Wastewaters are generated from contact water used to cool the rolls and steel, and are sent to the South Terminal WWTP (discussed above).

Solid wastes from the cold rolling mill arise from waste lubrication oils, scale, roll grindings from resurfacing of worn rolls (which may be hazardous waste due to chromium [D007]), and WWTP sludge (which may contain cadmium [D006], chromium [D007] and lead [D008]) (parenthetical comments from USEPA Sep95a pg. 25).

**Batch Annealing.** To restore or improve ductility the cold-rolled steel may be stacked and heated for 25-45 hours in a furnace. No water or solid wastes reportedly are generated from this batch annealing process at AK Steel. (USEPA Aug97 pg. 10).

**Temper Mills.** The steel strip may proceed to a temper mill where rollers reduce the strip thickness a few percent to improve product surface and mechanical properties.

At the temper mills wastewater is created during contact cooling of the rolls and steel. Solid wastes include waste lubrication oil, scale, roll grindings, and WWTP sludge. Waste streams are similar to those of the cold rolling mill. No particulars have been provided concerning the routing of temper mill waste waters or solids at AK Steel.

### **3.1.2.2 Steel Finishing**

At finishing mills protective coatings are applied to the steel surface. Surface cleaning steps generally precede the coatings. There are four finishing operations at AK Steel, of which the following two are located in the South Plant: electrolytic zinc and zinc/nickel alloy coating (No. 2 Electrogalvanizing Line or "EGL"), and aluminum coating (No. 4 continuous annealing hot dipped Aluminize Line). The coating lines prepare the steel surface using alkaline cleaning or acid pickling. Common alkaline cleaners in the steel industry include caustic soda, soda ash, alkaline silicates, and phosphates (USEPA Sep95a pg. 22). The Aluminize Line include an annealing operation prior to coating.

**Electrogalvanizing Line.** At the EGL zinc or zinc-nickel alloy is electrolytically deposited on the steel surface. EGL wastewaters include waste pickle liquor, and rinsewaters from cleaning and pickling, plating, and air scrubbing. The waste pickle liquor (K062) is used at the South Terminal WWTP for pH adjustment. The

## **Contaminants Released to Surface Water and Ground Water at AK Steel**

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rinsewaters, except from plating, also are sent to the South Terminal WWTP and discharged as described in Section 3.1.2.1. EGL plating wastewaters are sent to the relatively new EGL Treatment Plant.<sup><35></sup> Effluent from that plant is discharged via internal outfall 642 and external outfall 004 to North Branch Dick's Creek.

Solid wastes from the EGL include the sludges from South Terminal and EGL WWTPs. The South Terminal WWTP is discussed in Section 3.1.2.1. Sludge from the EGL Treatment Plant either is sold for zinc reclamation or—if derived from nickel-zinc coating—is classified hazardous (F006) and sent off-site.

Stormwater from the EGL vicinity discharges via outfall 004 to North Branch Dick's Creek.

**Aluminize Line.** At the Aluminize Line the steel is hot-dipped into a bath of molten aluminum. Waste rinsewaters are directed to the South Terminal WWTP. The fate of water and sludge from that treatment plant is discussed in Section 3.1.2.1.

Stormwater from the Aluminize Line vicinity discharges via outfall to 004 to North Branch Dick's Creek.

(PRC 11Dec92 Sects. 2.1.4, 2.2.4; USEPA Aug97 pp. 1, 9-11, Table 1-2; Arcadis 15Jul00 pg. 17; Arcadis 16Mar01 pg. 5).

### **3.1.2.3 Materials Handling**

Prior to the early 1960's AK Steel performed its slag processing in a large area west of the Hot Strip Mill (as identified by C. Batliner during site visit, 21May03). Stormwater in this area drains via outfall 015 to Dick's Creek (C. Batliner during site visit, 21May03).

A concrete plant also formerly operated within an unspecified area of South Plant Area.

An unlined 200 ft by 200 ft Solid Waste Transfer Area (SWMU 37) is located in the southeast portion of the South Plant Area. At SWMU 37 solid wastes formerly were accumulated prior to offsite disposal (PRC 11Dec92 pp. 78-79, App. A photos 64, 65), The area currently is used to store contractor equipment (C. Batliner during site visit, 5/20/03).

### **3.1.3 North Plant Area-Steel Finishing**

The North Plant Area provides additional finishing options for sheet steel from the Hot Strip Mill. These options currently includes at least one temper mill and two coating lines: the No. 2 Terne Coat Line and the Continuous Annealing Hot Dip Galvanizing Line (No. 3 Zinc Grip Line). The coating lines prepare the steel surface using alkaline cleaning or acid pickling (the latter mostly before 1973). Common alkaline cleaners in the steel industry include caustic soda, soda ash, alkaline silicates, and phosphates (USEPA Sep95a pg. 22). The galvanizing line includes an annealing operation prior to coating. The North Plant Area also contains three used-oil recovery plants and the North Terminal WWTP (SWMU 1).

At the time of the VSI the North Plant Area also contained two operating cold mills (No. 1 and No. 2), an additional zinc grip line (No. 1), and a paint grip line (No. 1)

## Contaminants Released to Surface Water and Ground Water at AK Steel

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(PRC 11Dec92 pg. 25).<36>

The former cold mills generated contact cooling wastewater; the temper mill generates contact cooling wastewater; theterne coat line generates alkaline rinsewaters, pickling rinsewaters, quench water, scrubber wastewaters, and waste pickle liquor; and the zinc grip line generates alkaline cleaning wastewaters, quench water, and scrubber wastewaters. Except for the waste pickle liquor, all of these wastewaters plus those generated at the used oil recovery plants are treated at the North Terminal WWTP. The waste pickle liquor is used for wastewater neutralization. Effluent from the North Terminal WWTP is discharged via internal outfall 614 and external outfall 011 to the Great Miami River (PRC 11Dec92 Fig. 6).

North Terminal WWTP sludge contains various metals. It was not EP toxic according to tests performed before or during 1980 (PRC 11Dec92 pg. 25). The sludge is sent to onsite landfills. Certain coating lines create spent material such as dross, terne coat flux filtration skimmings (D008, confirmed hazardous waste) and other wastes. Some of these wastes are stored in buildings within the North Plant (e.g., terne coat flux skimmings at SWMU 4, terne coat dross at SWMU 5). The terne coat flux skimmings are disposed of off-site.

Various rolling and lubricating oils are (or were) used in the former cold rolling mill and coating lines of the North Plant. The oil recovery plants (two were active as of the VSI) reclaim the oils for use as boiler fuel (similar to No. 6 fuel oil) or for coal bulk density control by spraying oil on coal being charged to coke ovens.

Stormwater from the North Plant Area discharges via outfall < > to < >. <not sure, could be be 011 or 003?resolve>

(PRC 11Dec92 Sects. 2.1.1, 2.2.1, Fig. 6; USEPA Aug97 p. 2, 10-11, Table 1-2).

### 3.1.4 Coil Paint Area-Steel Finishing

The Coil Paint Area has been sold to Materials Science Engineering except for the site of the former Coil Paint WWTP lagoons (SWMU 23). At the time of field activities in the VSI (1991) and Multimedia Inspection (1996) the Coil Plant still was a component of AK Steel. The Coil Paint Plant painted large coils of steel to customer specifications. The tubing and fabricating plants also located within the Coil Paint Area are not described in documents I have reviewed.<37>

The coil painting process generated wastewater and painting wastes including spent solvents and contaminated paints. Documents I have reviewed do not identify the solvents used at the Coil Paint plant. C. Batliner recalls that (at least) xylenes, toluene, and 2-butanone (methyl ethyl ketone or "MEK") were used (field trip 5/21/03).

Between 1971-1978 coil paint wastewaters passed through unlined treatment lagoons (SWMU 23) before discharging through an unspecified outfall to an unspecified water body. <resolve> Two of these lagoons removed suspended solids from the wastewaters and the third dewatered the resultant sludge. Lagoon sludge was sent to an onsite landfill. In 1978 the Former Coil Paint WWTP was constructed and the SWMU 23 lagoons were closed. The WWTP discharged its

## **Contaminants Released to Surface Water and Ground Water at AK Steel**

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effluent to the City of Middletown sewer system. In 1985 the WWTP was shut down; in 1986 the SWMU 23 lagoons were backfilled. At the time of the VSI (1991) Coil Paint wastewaters were stored in a surge tank (SWMU 22) and then pumped to the North Terminal WWTP. The fate of effluent and sludge from that WWTP is described in Section 3.1.3.

Various painting wastes, mostly spent solvents, were accumulated at four locations within the Coil Paint Area, including a storage shed (SWMU 26), the corner of an asphalt parking lot (SWMU 24), a satellite accumulation area (SWMU 27) and an accumulation tank (SWMU 25). Spent solids from the coil paint line include hazardous wastes F003/F005 and D001. A November 1992 OEPA inspection reported that the coil paint line generated 2500 pounds per month of solid wastes (F003, F005) and 5000 gallons per month of solvents (F003, F005). (OEPA 04Nov92; PRC 11Dec92 Sects. 2.1.3, 2.2.3).

Stormwater from the Coil Paint Area discharges via outfall < > to < >.  
<resolve>

### **3.1.5 Slag Processing Area**

The Slag Processing Area located south of Dick's Creek includes several landfills, numerous slag piles, mill scale piles, and various unit operations for processing slag, mill-scale, and other wastes or byproducts. Metals reclamation activities were begun here by McGraw Construction in 1965 (G&M May89 pg. 9; Arcadis 15Jul99 pg. 4) or between 1961 and 1966 (Arcadis 16Mar01 pg. 4). In 1985 International Mill Services, Inc. ("IMS") purchased McGraw Construction and assumed operations which at that time included refinement of raw slag, kish, and mill scale.<sup><38></sup> In January 2000 management of the area was taken over by Olympic Mills Services ("OMS"). AK Steel property surrounding the metals processing area is used to landfill solid wastes generated at the Middletown Works. Most of this waste is wastewater treatment sludges. Sludges are transported to the fills by rail. Other landfilled materials include slag, rubble, trash, tar decanter sludge (K087), open hearth sludge, and other industrial wastes. Waste oils previously were burned in pits located within some of the landfills. (PRC 11Dec92 Sects. 2.1.5, 2.2.5; USEPA 17Aug00 para. 18).

Part of the Slag Processing Area is known as the Olympic Mills Service ("OMS") Operations area. The OMS Operations area occupies the northwestern portion of the Slag Processing Area (Arcadis 16Mar01 Figs. 1, 2; Arcadis 08Feb02 pg. 2). Conditions in the OMS area are the subject of an Administrative Order ("AO") to AK Steel issued by USEPA on August 17, 2000. Arcadis (16Mar01) and Arcadis (08Feb02) describe soil and ground-water investigations planned and performed in response to that AO.

Most of the original land surface within the OMS area east of Monroe Ditch has been covered with slag and soil fill. Slag thickness ranged from 1 ft (at the Former Oil Separator Ponds) to 22 ft (at Mill Scale Area 3) as of approximately 1999 (Arcadis 15Jul99 pg. 26), and slag deposition activities have continued since then.

Mill scale generally has been managed in distinct areas in the central to eastern end of the OMS Area. The three current mill scale areas contain evolving mounds of mill scale. The scale either is obtained from rolling processes in the Hot Strip

## **Contaminants Released to Surface Water and Ground Water at AK Steel**

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Mill ("internal" mill scale) or is purchased from off-site sources ("purchased mill scale"). All three of the current mill scale areas have stored both internal and purchased mill scale. Lubricating oil is used during the rolling process and commonly covers the surface of mill scale. Prior to the late 1970s, some lubricating and insulating oils contained PCBs (Arcadis 15Jul99 pg. 17). According to AK Steel the oils used at the steel plant are "not expected" to have contained PCBs due to the absence of contrary documentation. I observe, however, that the "strict document retention policy in the 1980s" (Arcadis 16Mar01 pg. 5) might have destroyed any such records. AK Steel has noted that purchased mill scale may have contained oils with PCBs. After temporary storage in the Slag Processing Area, mill scale is recycled at high temperature in the Sinter Plant and blast furnace, or is sold. (Arcadis 15Jul99 pp. 17-19; Arcadis 16Mar01 pg. 5; Arcadis 08Feb02 pg. 7).

### **3.1.6 Unspecified Locations**

In addition to the wastes discussed above by area, Middletown Works also generates the following wastes and approximate amounts: petroleum naphtha from maintenance operations (D001, D039; 5000 lb/mo), cleaning liquids (D006, D018; 150 lb/mo), waste paint (D001; 1380 lb/mo), waste flammable liquid (D001; 14580 lb/mo), solid chrome waste (D007; 600 lb/mo) and chromic acid (D007; 110 gal/mo). Specific location, handling and storage procedures are not described in available documents. Eventually these wastes are shipped offsite. (OEPA 04Nov92).

USEPA (Sep95a Sect. IV) discusses sources and quantities of chemicals released or transferred offsite at steel production facilities. These tables summarize information from Toxic Release Inventories submitted to USEPA for the 1993 reporting year. For the purposes of the current report the tables provide a list of substances present in significant amounts at some steel facilities.

In particular, within the US iron and steel industry the chlorinated hydrocarbon solvents 1,1,1-trichloroethane ("111TCA")<sup><39></sup> and trichloroethene ("TCE") historically have been released to the air in substantial volumes (USEPA Sep95a pp. 31, 32, 34, 40). Use of these chemicals is not mentioned in AK Steel documents I have reviewed; however, they have been detected in some monitoring wells at the Site. Spills of such soluble, persistent compounds to the ground can lead to extensive, long-lasting ground-water contamination.

### **3.2 Evidence of Releases**

For each of the five Middletown Works areas, this section discusses evidence of potential or actual releases of hazardous wastes or hazardous constituents to the environment. Discussion is based both on historical records of spills, disposal activities, and other operational practices and on environmental sampling. The major plant areas are discussed in subsections 3.2.1 Melt Area, 3.2.2 South Plant Area, 3.2.3 North Plant Area, 3.2.4 Coil Paint Area, and 3.2.5 Slag Processing Area. Spills which originated onsite but discharged via plant sewers through NPDES outfalls to surface waters are addressed in subsection 3.2.6 NPDES Outfalls.

Principal sources of historical information on spills, disposal activities, and other operational practices include the PRC Preliminary Review/Visual Site Inspection

## Contaminants Released to Surface Water and Ground Water at AK Steel

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report (PRC 11Dec92)<sup><40></sup>, a USEPA corrective action stabilization questionnaire (USEPA 12June92), an OEPA hazardous waste management compliance evaluation inspection (OEPA 12Jan93), the USEPA 1997 multimedia inspection report (USEPA Aug97)<sup><41></sup>, AK Steel pollution incident reports to OEPA's Emergency Response Unit (November 1988 – March 1999) (OEPA 25Feb00, OEPA 01Dec99 Att. 3b; OEPA 24Jun03), and AK Steel reports concerning several particular releases (see the next paragraph). Extent of information on past practices and spills varies widely. Moreover, the “strict document retention policy in the 1980s” (Arcadis 16Mar01 pg. 5) apparently limits knowledge of activities during and prior to that time.

Some field studies have been performed at the Site to assess soil, surface-water, and ground-water quality or to infer location and severity of specific contaminant releases. These efforts have included mandated periodic effluent sampling at NPDES-permitted outfalls, approximately annual rounds of an evolving voluntary site-wide AK Steel ground-water monitoring network during 1991-2001 (missing data for 1993; OEPA 01Dec99 Att. 4c; Arcadis 05Sep01), a few samples of spilled waste collected by OEPA during site inspections, and targeted environmental media samples in response to certain specific release events. In addition a 1995 OEPA basin-wide study conducted sampling of surface water, sediment, and biological indicators in the Site vicinity including along Dick's Creek, North Branch Dick's Creek, and nearby Great Miami River (OEPA 30Dec97).

Each third-level section below begins by describing those Solid Waste Management Units (“SWMUs”) and Areas of Concern (“AOC”) at which—according to PRC (11Dec92)—spills have occurred in the past, the potential for current releases exceeds “low”, or a Sampling Visit (“SV”) is recommended to gather additional evidence of releases (PRC 11Dec92 pg. 2).<sup><42></sup>, <sup><43></sup> This is followed by, or in some cases interleaved with, discussion of non-SWMU areas with a history of spills or other releases. Finally, indented fourth-level sections describe the events, including sampling results if available, for certain specific release locations.

### 3.2.1 Melt Plant

PRC (11Dec92) identifies 12 SWMUs in the Melt Plant Area and notes evidence of actual or potential releases at seven of them: SWMUs 11, 15, 16, 17, 19, 20, and 21. PRC (11Dec92) also identifies five AOC in the Melt Plant Area.

The two **Blast Furnace/Sinter Plant Wastewater Treatment Sludge Ponds (SWMU 11)** receive wastewaters from the blast furnace Dorr thickener, blast furnace cast house floor, sinter plant venturi scrubber, and the water softener system. The ponds, built in 1952, may once have been clay lined (no documentation available). However, the biweekly dredging of the ponds may have removed any such liner (C. Batliner 20May03 during site visit). The VSI observed that sludge in a drainage swale adjacent to the east side of east SWMU 11 appeared to have resulted from overflow of the pond. In addition if inadequately lined, the ponds may leak through the bottom releasing contaminants to the soil and ground water. PRC rated the potential for current releases from this area as moderate-to-high due to noted overflows, lack of lining, and many years of operation; an SV is recommended. (PRC 11Dec92 pp. 37-39, 103, 131).

## **Contaminants Released to Surface Water and Ground Water at AK Steel**

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The **Coal Tar Decanter Sludge Recycling Area (SWMU 15)** received and recycled decanter tank tar sludge (K087) generated from the coking operation. This activity began in late February 1990 and continued to 1995. (Previously K087 waste was sprayed directly into the coal storage pile; see SWMU 17). In September 1990 Ohio EPA noted releases via PVC pipes which drain the bermed, concrete-floored containment sub-area. During the VSI PRC observed extensive coal tar spillage inside and outside of the bermed area. PRC rated the potential for current releases from this area as high due to observed spillage of sludge on soils, contaminated runoff from the concrete pad, and the OEPA inspection results. An SV is recommended, targeting soils outside of the bermed area. (PRC 11Dec92 pp. 44-45, 46, 106, 133).

The **Coal Tar Decanter Sludge Collection Bins and Drop Box (SWMU 16, AOC 3)** are used to collect and contain K087 waste and are located next to the coking batteries. Originally the bins carried waste to the Robin Hood Coal Pile. Between February 1990 and 1995 the bins were used to convey the waste to recycling area SWMU 15. Subsequent to that time <what is done now?>. On January 9, 1990 OEPA collected samples of K087 wastes which were found on the ground in the drop box and collection bin areas, apparently before concrete pads were built in these areas. The samples contained organic compounds characteristic of K087 waste in concentrations from 1.3 to 100 parts per million ("ppm").<sup><44></sup> A sample of "sludge spread liberally across the (concrete) pad adjacent to the coal tar decanter boxes" in November 1992 contained 17000 parts per billion ("ppb") benzene (OEPA 12Jan93 pg. 2; ). PRC rated the potential for current releases from this area as high due to past routine spillage; an SV is recommended. (PRC 11Dec92 pp. 45-46, 106, 133).

AK Steel formerly unloaded coal tar decanter tank sludge (K087) directly onto the east end of the **Coal Storage Pile (K087 sprayed) (SWMU 17)**, also known as the Robin Hood Coal Pile (OAG 29Jan98 Sect. E.1). This area was identified as a RCRA hazardous waste storage area; it is discussed in Section 3.2.1.4.

The broader **Coal Storage Area**, of which the Robin Hood Coal Pile was a part, has existed for decades and constitutes a likely source of surface water, soil, and ground-water contamination. Coal pile runoff typically has a low pH created by oxidation of sulfide impurities in the coal to sulfuric acid of (similar to acid mine drainage). Coal contains heavy metals such as arsenic, copper, nickel, lead, and zinc which can be mobilized by low pH. There is no natural or man-made liner beneath the coal or beneath the downstream Coal Pile Spray Pond. Therefore, absent natural buffering capacity (such as carbonates) in the underlying soils, it is likely that heavy metals contamination exists in soil and ground water beneath the coal pile and perhaps beneath the Coal Pile Spray Pond.<sup><45></sup>

The **Former Used-oil Storage Area (SWMU 19)** at the former open hearth wastewater treatment plant has a concrete floor with no secondary containment. Used oil from various processes was brought to SWMU 19, mixed with fuel oil, and stored in 55-gallon drums until reused. The VSI observed two leaky drums at this location. PRC rated the potential for current releases from this area as moderate-to-high due to the observed drums in poor condition, stains around the drums, and absence of secondary containment. An SV is recommended targeting soil near the storage pad. (PRC 11Dec92 pp. 49, 108, 135).

## **Contaminants Released to Surface Water and Ground Water at AK Steel**

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The **Benzol Tank Farm Area (including tar tank sludge storage area) (SWMU 20)** was located in the coke plant's former by-product recovery facility. The tank farm was used to store benzene and various fuels. The benzol plant was shut down in 1984 due to poor economic conditions for its products. During the VSI the tanks were empty but some tank secondary containment areas contained unknown red- and green-colored solutions indicating releases of tank contents. One semi-bermed area of the tank farm, formerly the site of a tank, was being used to hold tar storage tank sludge (K142) removed from the AOC 2 storage tanks. PRC rated the potential for current releases from this area as moderate-to-high due to the colored liquids in secondary containment areas and soil stains near the accumulated coal tar; an SV is recommended. (PRC 11Dec92 pp. 50-51, 108, 135).

The **Used Oil Accumulation Area (by Sinter Plant) (SWMU 21)** stages drums of used oil prior to recycling. The asphalt floor has no secondary containment. Oil-stained soil was observed near the drums during the VSI. PRC rated the potential for current releases from this area as high due to the stained soil and absence of secondary containment; an SV is recommended. (PRC 11Dec92 pp. 51-52, 136).

As of the VSI the **Tar Storage Tanks (AOC 2)** consisted of two aboveground steel tanks which stored coal tar from the Coke Plant. The 40-ft tanks sat on bare soil in a semi-bermed area; coal piles were adjacent. The tanks appeared to have been patched suggesting past leaks. AK Steel has not provided any information concerning integrity of the tanks.

AK Steel places the installation of these tanks in 1952, construction of earthen dikes around the tanks in the early to mid-1960s, and tank volumes at 600,000 gal and approximately 650,000 gal (G&M 27Mar92 pg. 5). Periodically the tanks are cleaned out and waste is recycled to the coke ovens. This cleanout material is a listed hazardous waste (K142). In November 1990 Ohio EPA observed an estimated 13,000 gallons of cleanout waste on the ground within the bermed area surrounding the tanks. The waste was being pumped to tank trucks for on-site recycling. As of 1992 or 1993 one of the tanks was removed and an outer containment shell was installed around the remaining tank (C. Batliner 20May03 during site visit). Three documented tar spills at the tanks or tar loading station occurred in 1992 (500 gal.) and 1994 (30 and 100 gal.) (OEPA 01Dec99 Att. 3b). PRC rated the potential for current releases from the tanks as low; however, an SV is recommended. (PRC 11Dec92 pp. 89-90, 110, 148).

The **Rail Car Transfer Area (AOC 4)** in the former benzol plant was the site of transfers of recovered products (e.g., benzene, naphthalene, light fuel oil) from the plant to railroad tanker cars. Routine spillage of these materials may have occurred at this location. PRC rated the potential for current releases from this area as moderate; an SV is recommended. (PRC 11Dec92 pp. 90-91, 110, 149).

The **Flushing Liquor Sump (AOC 6)** is a concrete pit built in the 1960s which collects both flushing liquor generated from processing coke plant off-gases and runoff from the coal tar decanter sludge collection bins area (SWMU 16). The flushing liquor, produced by spraying water onto hot coke gases, contains primarily ammonia and phenol and also metals and other organics associated with coking byproducts. Pyridine and selenium have been found in the AK Steel

## **Contaminants Released to Surface Water and Ground Water at AK Steel**

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flushing liquor at EP toxic levels. (Also see Section 3.2.1.3). During the VSI pools of green-colored liquid (presumed to be ammonia-containing liquids) were observed next to the sump.<sup><46></sup> PRC rated the potential for current releases from this area as moderate due to the observed pools of liquid, the possibility of routine spills or overflows from the various hoses and the apparently large volume transferred into this area; an SV is recommended. (PRC 11Dec92 pp. 92-93, 111-112, 150).

### **3.2.1.1 Coke Oven Gas Pipeline Leak**

A spill from a leaking Coke Oven Gas ("COG") fuel pipeline in the southwest corner of the Melt Plant area first was detected on January 24, 1996. The leak may have been occurring for some time but only became evident when the ground froze and the gas migrated beneath the surface into nearby residential basements. Carbon monoxide was detected in homes at 3103 and 3109 Ottawa Street, which runs along the western boundary of the facility. Both homes were evacuated. At 3109 the atmosphere also contained explosive gases at 77% of the lower explosive limit ("LEL"). After excavating a hole through the frozen ground on AK Steel property and detecting the odor of COG, AK Steel closed a valve feeding the pipe segment, "implemented measures to purge remaining gasses", and blanked (sealed) the pipeline at three locations to isolate the segment. Subsequently AK Steel removed the affected portion of pipeline, installed a passive ventilation system in the excavation, and backfilled the trench. (Dames & Moore 23Jul98; Frost & Jacobs 21Jun96).

In March 1996 a soil gas survey was performed by Bennett & Williams, an environmental consultant for the residents. Potentially explosive vapors were detected in the soils at 3109, 3103 and 3027 Ottawa St. (Altman & Calardo Co. 05Mar86). AK Steel conducted a more extensive soil gas survey with similar results (Environmental Risk Management 18Mar96; Dames & Moore 22Mar96 pg. 2).

During mid-April 1996 AK Steel installed a soil vapor extraction system (Dames & Moore 30Apr96). The location of the system apparently was selected to address vapors beneath the residences of the three litigating property owners rather than as a source remedy (Dames & Moore 22Mar96 pg. 4; 03Apr96 pg. 5, Fig. 4). According to AK Steel consultant Dames & Moore the SVE system successfully removed all COG constituents from soils in the vicinity of the release (Frost & Jacobs 05Sep97 pg. 2); however, I have not seen determinant data on the location of the release. Given the high concentrations of benzene elsewhere along the pipeline (see below), it seems possible that more than one leak existed and/or that the COG traveled along the pipeline backfill for a substantial distance beyond the reach of the SVE system. The SVE unit was shut down on March 30, 1998 (Dames & Moore 29Apr98 pg. 1).

In April 1996 AK Steel and its consultant "strongly believe[d] that it [was] premature to consider any groundwater monitoring" and was not convinced "whether this is even necessary" (Frost & Jacob 16Apr96). Nevertheless in April 1996 Bennett & Williams, an environmental consultant to former residents of 3027, 3103, and 3109 Ottawa Street, installed three wells (BW-1 through BW-3) into the Upper Saturated zone at 3103 Ottawa Street. The two wells closer to AK Steel detected benzene at high concentrations (38000 and 8000 ug/l). (Altman &

## **Contaminants Released to Surface Water and Ground Water at AK Steel**

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Calardo 16Apr96; Dames & Moore 23Jul98 pp. 4-5, 8-9, Table 2, Figure 2). The data indicated that benzene had migrated offsite from AK Steel and had contaminated ground water including beneath residential property along Ottawa Street. AK Steel subsequently purchased and demolished <true for all three?> these three houses.

In May and June 1996 AK Steel performed an upper aquifer ground-water investigation at the COG leak site. Twenty-two push-probe borings (Geoprobe and Simco, "DMP-#") were used to collect soil samples for lithologic classification and water samples for chemical analysis. The push-probe soil samples indicated that in this vicinity the regional Upper Aquifer is divided into two units. The shallower unit is referred to as the Upper Saturated zone (the "shallow" wells in this study area, e.g., DMW-4s, are screened in this Upper Saturated zone). The deeper unit retains the regional Upper Aquifer name (the "deep" wells in this area, e.g., DMW-1d, are open to it).<sup><47></sup> The two units are separated by a relatively continuous silty clay encountered 17 to 30 ft bgs with a thickness ranging from "less than a few feet, possibly becoming discontinuous" to over 20 ft (Dames & Moore 23Jul98 pg. 4). During June 1996 four shallow and three deep monitoring wells were installed by AK Steel and sampled for benzene, toluene, ethylbenzene and total xylenes ("BTEX"). Each of these COG constituents was detected, and three of them at least once exceeded 1000 ug/l. Benzene was by far the most prevalent, persistent, and concentrated contaminant (up to 64000 ug/l at well DMW-3s; the VAP standard is 5 ug/l).

AK Steel installed a ground-water extraction network into the Upper Saturated zone behind (east of) residences along Ottawa Street. This "pilot ground water pumping and treatment system" began operation with four extraction wells on February 6, 1997. Volatile and semivolatile organic compound analyses (Methods 624, and 625, respectively) collected at each extraction well on the 6<sup>th</sup> detected only benzene. A February 7<sup>th</sup> sample of treatment plant influent analyzed for priority pollutants also found "no indication of ground water impact other than the COG constituent benzene" (Dames & Moore 23Jul98 pg. 10). Additional monitoring wells were added in April/May 1997. One of these (DMW-11), located to the north of existing wells, detected 21000 ug/l benzene. In response, in July 1997 a fifth extraction well (EW-5) was added nearby to extend the zone of capture further northward. The two available samples from EW-5 have contained 7000 and 9400 ug/l benzene, the latter more recently in April 1999 (Dames & Moore 12Jun99 Table 2).

In addition in March 1998 a vacuum-pumped 12-wellpoint extraction system was implemented offsite near the southern end of the plume. Over a two day period each wellpoint was pumped for approximately 4 hr, and then the system was removed. Available documentation does not describe whether anything useful was accomplished.<sup><48></sup> (Dames & Moore 29Jan98; Dames & Moore 23Jul98 pg. 11).

In December 1998 three additional extraction wells (EW-6, 7, 8) were brought on-line: two at the north end of the plume and one in the south. Presumably the northern wells were meant to help address the persistently high concentrations at DMW-11 and EW-5, and the southern well was intended to control the recently observed benzene breakthrough at BW-3. BW-3 is the well located farthest from AK Steel on the former residential property. BW-3 first exhibited breakthrough of

## **Contaminants Released to Surface Water and Ground Water at AK Steel**

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benzene (110 ug/l) in September 1998 approximately 2 ½ years after the release (ENSR 21Apr03 Table 2). This demonstrated that the existing extraction system was not containing the benzene plume.

Through May 18, 1999 an average 1120 gallons per day (0.78 gpm) had been withdrawn from the aquifer; however, mechanical problems and low ground water levels at times have reduced flow substantially (e.g., to 175 gpd, or 0.12 gallons per minute, during February-March 1998 [Dames & Moore 29Apr98 pg. 2]). As of June 1999, hydraulic mounding indicative of operational problems was occurring at two of the northern extraction wells (Dames & Moore 21Jun99).

I am not convinced that the installed ground-water extraction system at the COG pipeline spill area created a zone of capture which covered much of the contaminated area at all. An extraction rate of less than 1 gpm—total—obtained from up to eight wells is very low. Hydraulic evidence of any influence from the pumping is scanty and incomplete. A two-hour pumping test of EW-2 conducted on February 6, 1997 just before system startup purportedly detected drawdown 100 ft away at P-3 (Dames & Moore 23Jul98 pg. 10); however, no supporting data are provided. The induced zone of capture purportedly “almost certainly exceed[ed] 50 ft along the property boundary and ? most likely extend[ed] beyond 120 ft in all directions” (Dames & Moore 23Jul98 pg. 10); however this claim is not justified in either Dames & Moore (23Jul98 pg. 10) or its cited source Dames & Moore (19Jun97). Water elevation data for the monitoring wells and piezometers do not exhibit any apparent effects from the pumping activities (Dames & Moore 23Jul98 Table 1).

Through April 1999 extraction well benzene concentrations and trends varied spatially. In the south, where initial monitoring well concentrations had been highest (up to 64000 ug/l), the extraction wells initially contained relatively lower concentrations (less than 1000 ug/l benzene) and declined to non-detectable levels. Most southern monitoring well concentrations also declined by orders of magnitude over the same period. The exception is well BW-3, as discussed above. In the most recent available sample (April 1999) BW-3 had declined to 7 ug/l benzene from its maximum of 110 ug/l. In the north, initial monitoring well benzene concentrations were elevated in one location (DMW-11, 21000 ug/l), and elsewhere did not exceed 30 ug/l at any time. Conversely, extraction well concentrations in the north have been stable or even rising (EW-3 up to 5200 ug/l; EW-5 up to 9400 ug/l, EW-6 up to 19000 ug/l). The most contaminated monitoring well as of April 1999 was northern well DMW-11 which had varied only slightly historically within the range of 16000 - 21000 ug/l benzene. (Frost & Jacobs 05Sep97; Dames & Moore 21Jun99).

In April and August 2000 chemical oxidation treatments were conducted in the northern portion of the upper shallow aquifer. Chemical oxidation, if successful, converts target contamination to innocuous chemicals such as carbon dioxide and water. On October 9, 2000 the extraction well system was disengaged to allow the chemical reagent to react in the subsurface. The procedure achieved large reductions in benzene: most monitoring well concentrations were reduced to nondetectable levels. As of November 2002 three extraction or monitoring wells still contained detectable benzene. Well EW-7 has rebounded strongly from the oxidation, exhibiting 120 ug/l after having been nondetect since November 2000. At EW-6 (6.9 ug/l) benzene has been declining consistently since the oxidation

## **Contaminants Released to Surface Water and Ground Water at AK Steel**

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treatment. And at well BW-2, located in the south end of the site out of reach of the chemical oxidation treatment, benzene reappeared at a concentration of 2 ug/l. Benzene at this location was quite high in the years immediately after the spill (up to 7700 ug/l in November 1997), subsequently declined to nondetectable by April 1999, and remained nondetectable until the most recent sample in November 2002.

The persistence of benzene in the northern area (prior to chemical oxidation) belies an earlier AK Steel belief that natural attenuation would clean up the contaminated ground water at this location (Dames & Moore 20Jun97 pp. 9-11). Moreover, groundwater chemistry results used to support the natural attenuation argument (ibid. Table 4) do not show a consistent picture: the attenuation indicators of low dissolved oxygen, low Eh, and high ferrous iron occur at both contaminated and uncontaminated (e.g., DMW-1d) wells.

(Frost & Jacobs 05Sep97; Dames & Moore 29Jan98, 29Apr98, 23Jul98, 28Sep98, 14Jan99, 21Jun99; ENSR 30Sep02, 21Apr03).

### **3.2.1.2 Coal Tar/Benzene Release**

In November 1989 during a site-wide groundwater survey the first sample from upper aquifer monitoring well GM-04S was found to contain 700 ug/l benzene. <sup><49></sup> GM-04S is located in the southwest corner of the Melt Area. In response to this discovery, during 1991-1992 AK Steel consultant G&M performed a two phase "benzene investigation". Annual ground-water monitoring has since been conducted. (G&M 27Mar92; G&M 06Nov92; G&M Sep97; OEPA 01Dec99 Att. 4c).

AK Steel believes that the source of benzene in the ground water in this area is associated with the two coal tar storage tanks (AOC 2) installed in 1952. The cause and date of initiation of leakage are not discussed in provided documents, and no soil sampling in the source area is mentioned. <sup><50></sup> The tanks are patched, suggesting past leaks (PRC 11Dec92 pp. 89-90). Documented spills occurred at the tar tanks in 1992 and 1994 (OEPA 01Dec99 Att. 3b).

The Phase I benzene investigation involved aquifer "slug" testing, Hydropunch sampling, installation and sampling of four monitoring wells (GM-50S through 53S), and limited computer modeling. AK Steel concluded that a plume of dissolved benzene less than 725 ft wide (east to west) exists in the upper aquifer and has migrated offsite south of Oxford Rd (G&M 27Mar92 pg. 22, Fig. 15). AK Steel apparently then acquired property south of Oxford Rd (G&M 06Nov92 Fig. 3) and in the Phase II investigation installed additional monitoring wells GM-54S through GM-56S within that property. From boring samples in both investigations AK Steel concluded that no till exists between the surface and the upper aquifer in the vicinity of purported source AOC 2, but that such a till aquitard arises near GM-52S and extends to the south, possibly beneath and beyond Dick's Creek. <sup><51></sup> From ground-water sampling results AK Steel concluded that a plume of benzene exists within the upper aquifer unit, and that this plume has migrated south-southwest from the vicinity of the GM-04S. The most contaminated well, GM-52S, has contained up to 1600 ug/l benzene in annual monitoring.

The lateral boundaries of the benzene plume are not fully defined. Although the

## **Contaminants Released to Surface Water and Ground Water at AK Steel**

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coal tar storage tanks are proposed as the source, this has not been confirmed by any type of sampling, and the upgradient extent of the plume has not been delineated by ground-water sampling. The eastern limit of the benzene plume is defined to some extent by clean samples from Hydropunch CT5C and well GM-56S; however there is no clean well north of CT5C. The western boundary of the benzene plume north of Oxford State Road appears to be adequately defined by clean samples from GM-51S and GM-53S (assuming they tap the correct aquifer). However, the western extent of the plume is not determined south of Oxford Road where piezometric data imply that migration is strongly westward. <52> It is likely that the plume extends beneath unsampled properties west of the newly purchased land parcel. Finally, the southern limit of the plume is unknown. Based on sampling, the phase II study concludes that the benzene plume has not traveled as far as Dick's Creek and that the upper aquifer possibly is insulated from overlying Dick's Creek by about two feet of intervening till. However, because phase II sampling south of Oxford State Road was confined to the newly purchased parcel, it did not track the plume to its likely more westerly intersection with (or beneath, or beyond) Dick's Creek. (G&M 06Nov92 pp. 15, 17, Figs. 6, 10). This oversight compromises AK Steel conclusions on the southern extent of the plume. Moreover, there is no question that sufficient time has passed for ground water to have reached Dick's Creek from the coal tar storage tanks: G&M modeling indicated a travel time of one to three years (G&M 27Mar92 pg. 16).

During the phase I and phase II investigations and subsequent monitoring, the chlorinated hydrocarbon 1,2-dichloroethene ("12DCE") has been detected in four of the "benzene investigation" wells. 12DCE has been present multiple times in GM-04S (1990, 1991 (twice), 1995, and 1997) at a maximum concentration of 18 ug/l, in GM-50S (6J ug/l), in GM-54S (5J ug/l), and in GM-55S (6J ug/l). Well GM-50S also contained chloroform in 1999. The source and extent of the 12DCE ground-water plume have not been determined (G&M 06Nov92 pg. 14).

Over the course of monitoring, benzene concentrations have declined to nondetectable levels (through April 2001) at all five affected permanent monitoring wells even though no remedial measures have been taken (Arcadis 05Sep01). Based on geochemical parameters at two (1995) and four (1997), respectively, of the contaminated wells, G&M previously inferred that intrinsic bioattenuation (natural microbiologically-mediated decay) is responsible for the decline. (G&M Sep97).

### **3.2.1.3 Flushing Liquor Spills to Land**

Flushing liquor is created during coke production (Section 3.1.1). Five reported spills of flushing liquor occurred at AK Steel between 1990 and 1995. Available documents specify the locations of some, but not all, of the reported spills. During a May 20, 2003 site visit C. Batliner took us to the spill locations and stated that all five spills occurred within the Coke Plant, four of them in essentially the same location (adjacent to a partially below-grade building which formerly housed flushing liquor decanter tanks, and which now is filled to light-fixture-level with water) and the fifth (on July 26, 1995) nearby.

Four of the five documented flushing liquor spills entered the plant stormwater sewer system and emerged at Dick's Creek. The outfall receiving spilled flushing

## **Contaminants Released to Surface Water and Ground Water at AK Steel**

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liquor is either reported incorrectly or differs for the spills. Both outfalls 002 and 003 are mentioned.<sup><53></sup> All of the spills ran overland before entering the sewers and therefore in part may have infiltrated into the subsurface. Those spills traveling to outfall 003 apparently passed through an unlined impoundment later named the Coal Pile Spray Pond; infiltration may have occurred through the pond bottom.

The spilled flushing liquor at AK Steel has been sampled and characterized several times. A summary of detected compounds is provided in Table 3-1.<sup><54></sup> The analyses indicate that ammonia, naphthalene, methylphenols, BTEX, numerous PAHs, and other compounds are present in the liquid.

(Ohio Atty. General 25Feb00; OEPA 01Dec99 Att. 3b; OEPA 26Jul95; OEPA 12Jan93 pg. 3; OEPA PIR #05-09-1717).

### **3.2.1.4 Robin Hood (K087-sprayed) Coal Storage Pile Area**

SWMU 17—a portion of the so-called Robin Hood coal pile—formerly was soaked with recycled coal tar decanter tank sludge. The sludge is a listed hazardous waste (K087) and also contains multiple RCRA hazardous constituents. This activity began in early 1983 and ceased on February 23, 1990. The Robin Hood Coal Pile subsequently was removed; OEPA identified the area it occupied as a hazardous waste storage area.<sup><55></sup>

Because the underlying soils and ground water beneath SWMU 17 potentially were contaminated with hazardous constituents present in K087, AK Steel undertook closure activities. "Clean closure" of the former Robin Hood Coal Pile area recently was completed, and this closure has been accepted by OEPA (CCA 19May00; OEPA 13Jun00). The intent of the closure was only "to verify that K087 had not been released to underlying soil or groundwater" (CCA 19May00 pg. 15). Pointedly, it was not to demonstrate that soil or ground water was clean or within acceptable risk levels within this materials storage area.

Unfortunately, the closure study did not identify a way to distinguish K087 waste from the residues of other materials deposited on the soils in this area and in the broader materials storage area, including formerly stored tar (in pits), stored coal, and stored petroleum coke or "Petcoke". Lacking a chemical fingerprint unique to the K087 waste, the study resorted to comparisons of investigatory soil samples against background concentrations for the many hazardous constituents common to both K087 waste and these stored materials. The derived background concentrations were based on levels detected in soils outside of the footprint of the former Robin Hood Coal Pile.<sup><56></sup> Because the other stored materials also released considerable contamination to the soils, the derived background limits have high values. For instance, the background limit for benzene, naphthalene, five carcinogenic PAH's,<sup><57></sup> and bis(2-ethylhexyl)phthalate each exceeds the respective Ohio VAP single chemical standard assuming commercial/industrial land use.<sup><58></sup> Using the derived background levels, with no adjustment for cumulative effects of multiple chemicals, only a single investigatory soil sample was found to potentially reflect K087 waste. Approximately 27 cubic yards of soil in the affected area was excavated and disposed of offsite. The area was backfilled with "clean low-permeability stockpiled soil, compacted, and returned to use as a

## **Contaminants Released to Surface Water and Ground Water at AK Steel**

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coal pile" (CCA 19May00).

The Robin Hood Coal Pile closure investigation did not collect any samples of ground water. Borings to 20 ft bgs did not encounter saturated conditions, and no deeper holes were attempted. Therefore no information is available on the quality of the ground water beneath or downgradient of the coal pile.

Stormwater drainage from the K087-contaminated coal pile previously drained west to a storm drain on the west end of the coal pile and ultimately discharged via the Coal Pile Spray Pond and outfall 003 to Dick's Creek. Uncharacterized drainage improvements were made some time between December 1991 and November 1992. At the time of my site visit saturated, puddled, mushy conditions existed at the coal pile area. I was told that runoff is passively contained within the area (i.e., no vacuum pumping or other active stormwater management is performed).

Prior to coal storage in this area, AK Steel maintained two lagoons at and beyond the east end of the (then future) Robin Hood Coal pile. The lagoons, identified from ca. 1962 aerial photographs, reportedly stored coal tars but not K087 waste. (CCA 19May00 pg. 2, Fig. 2). If coal tar seeped from the lagoons into the subsurface, then soluble hazardous constituents of the tar could continue to contaminate infiltrating precipitation and underlying ground waters for many years. <59>

PRC rated the potential for current releases from SWMU 17 as high. At that time a closure plan had been submitted to OEPA; therefore no independent SV was recommended.

(Armco 19Jul90; OEPA 17Dec91 pp. 2-3; 04Nov92; PRC 11Dec92 pp. 9, 46-47, 107, 135; USEPA Mar00 pg. 2; CCA 19May00).

### **3.2.1.5 Diesel Spill in Train Derailment**

At approximately 4am on November 22, 1992 a railroad tanker car derailed along track located between the Melt Area and South Plant Area. An estimated 2500 gallons of diesel oil was spilled onto the ground. Heavy rains were occurring at the time. Oil appeared in a drainage swale 30 ft north of the site; pads and booms were deployed. Later in the day a 30-ft long interception trench was dug, into which oil migrated "at a good rate" and was removed by vacuum truck. Over 15000 gal of product and water had been removed by November 23<sup>rd</sup>.

Native clay was evident three feet bgs; the OEPA on-site coordinator stated that "this stopped any vertical migration of oil". Product continued to flow into the interception trench for at least one to three weeks (the documentation is ambiguous). Contaminated ballast and soil were removed, stockpiled, and tested for disposal. On December 14<sup>th</sup> AK Steel requested that it be permitted to backfill the interception trench with gravel and install a collection sump adjacent to the track bed. Available documents do not indicate whether the sump construction actually occurred. (OEPA 01Dec99 Att. 3b; OEPA 24Jun03).

No ground-water sampling was performed at the spill site (C. Batliner during May 2003 field trip). A substantial spill such as this typically does contaminate

## **Contaminants Released to Surface Water and Ground Water at AK Steel**

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underlying shallow ground water, notwithstanding clayey materials in the soil profile. Furthermore, lenses of sand and clay may form stratigraphic pockets which trap spilled oil, gradually releasing soluble constituents over many years.  
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### **3.2.2 South Plant Area**

PRC (11Dec92) identifies 10 SWMUs in the South Plant Area and notes evidence of actual or potential releases at two of them: SWMU 33 and SWMU 37. PRC (11Dec92) also identifies one AOC in the South Plant Area: AOC 7. I have added comments on SWMU 29 and the former slag processing area.

The **Spent Pickle Liquor ("SPL") Tank Farm (SWMU 33)** consists of three reinforced fiberglass vertical tanks used to store SPL. Total tank capacity is 160,600 gallons. Secondary bermed-concrete containment of approximately 85,000 gallons surrounds the tanks. SWMU 33 was constructed during 1969-70 and is active. SPL is pumped to a filtration system (SWMU 34) and then into deep injection wells (SWMUs 35 and 36). In addition some SPL is sent to the South Terminal Wastewater Treatment Plant (SWMU 28), to Armco's Ashland KY plant <61>, and to the city of Middletown sewage treatment plant for use as an oil treatment chemical. In or before 1991 Ohio EPA noted evidence of spills and leaks at SWMU 33 and that concrete in and around these tanks is visually stained, severely etched, and spalling. PRC rated the potential for current releases from this area as low due to secondary containment and apparently good condition of the tanks; no SV is recommended. (PRC 11Dec92 pp. 72-73, 76, 118, 142).

#### **3.2.2.1 Spent Pickle Liquor Spills to Land**

Ten documented spills of SPL to ground have occurred in the vicinity of the SPL tank and pipelines in the northeast corner of South Plant Area. All of these spills occurred due to pipeline failures before the SPL pipeline was upgraded to double-wall pipe in 1998. All but one of the spills reportedly occurred in an area where the SPL drained into a large unlined u-shaped depression that kept the liquid from migrating offsite. The remaining spill (April 1997) entered a ditch which led to an outfall to Dick's Creek (see Section 3.2.6.3). (C. Batliner 21May03 during site visit).

It seems likely that spilled SPL infiltrated into the ground, which was in some cases dry before the spill (e.g., the 01Feb89 spill). High acidity (low pH) usually solubilizes and mobilizes metals in ground water. At AK Steel such a metals-enriched ground water could include metals from within the spilled fluid and metals from the fill and native soil.

Used pickle liquor also enters the environment as spills of pickle rinse water ("PRW"). In December 1989 PRW with a pH of 2 (acid) escaped at 600 gpm for 6 hours (total 216,000 gallons) through a separated pipe weld into drainage ditches. Documentation is vague, but it appears that most of the fluid flowed through a limestone-plugged culvert and then offsite. The amount of infiltration was said to be restricted by the cold but was not otherwise evaluated. Infiltration was occurring: mobile equipment removed about one foot of contaminated soil from the drainage ditch. (OEPA PIR #12-9-4578).

## **Contaminants Released to Surface Water and Ground Water at AK Steel**

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The **Solid Waste Transfer Area (SWMU 37)** is an unlined 200 yd square area formerly used to stage solid wastes from different areas within the Armco facility prior to pickup by a waste hauler/recycler. Discarded materials included paper trash, scrap metals, drums, oil-contaminated soils, grease, railroad ties, and general refuse. During the VSI sporadic soil stains were visible over the entire area. Soil contamination potentially occurred from wastes stored in the area and from spills from drums containing grease and unknown wastes. PRC rated the potential for current releases from this area as high due to waste placement on bare soil, absence of secondary containment, and observed evidence of numerous spills and stains; an SV is recommended. (PRC 11Dec92 pp. 78-79, 120, 144).

The **Area by Aluminum Coating Building (AOC 7)** is a 40 ft square fenced area behind the Aluminum Coating building. Miscellaneous debris (rags, metal parts, wood, other trash), half-empty drums, and spills of oily liquid were noted during the VSI. A 3-inch granular layer underlay the drums. Debris and trash also were present outside of the fenced area. There was used oil in a nearby tank. Apparently Armco had stored used oil or other oily wastes in the area. PRC rated the potential for current releases from this area as high due to observed evidence of spills and absence of secondary containment; an SV is recommended. (PRC 11Dec92 pg. 94, 120-121, 150).

The **South Terminal Wastewater Treatment Polishing Ponds (SWMU 29)** are unlined and of uncertain but apparently considerable age; it is not known whether the ponds contain appreciable sludge (PRC 11Dec92 pg. 67). Although PRC (11Dec92) did not recommend an SV, in my opinion the possibility of infiltration of contaminants to ground water should prompt further investigation of SWMU 29.

The **Former Slag Processing Area** within South Plant Area operated prior to approximately 1965. I am unaware of any soil or ground-water sampling data from this location. If operations and materials were similar to those handled at the current Slag Processing Area, it is possible that PCBs, PAHs, and other contaminants found in the current Slag Processing Area also may be present in the fill, suspended sediment in storm runoff, and ground water beneath the former slag processing area.

### **3.2.3 North Plant Area**

PRC (11Dec92) identifies nine SWMUs in the North Plant Area and notes evidence of actual or potential releases at two of them: SWMU 3 and SWMU 4.

The **Terne Coat Flux Hazardous Waste Storage Area (SWMU 3)** temporarily stores flux skimmings from the terne coating operation. As of a November 1992 OEPA inspection approximately 13000 lb/mo of terne flux skimmings were being generated (OEPA 04Nov92). This waste is hazardous due to its EP toxicity for lead. Up to about 30 fifty-gallon drums of the skimmings, transported from SWMU 5, are stored indoors on wooden pallets over partially paved flooring. A 4-inch berm partially surrounds the area. In 1989 Ohio EPA noted spillage from a drum in this area; Armco then cleaned the spillage. The VSI documents floor stains which suggest other past spills of flux skimmings. PRC rated the potential for current releases from this area as low due to containment inside a building, easy detection, and easy cleanup; no SV is recommended. (PRC 11Dec92 pp. 28-29, 99, 127).

## **Contaminants Released to Surface Water and Ground Water at AK Steel**

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The **Terne Coat Dross Bucket Storage Area (SWMU 4)** cools and temporarily stores dross generated in the terne coating operation. The dross, which contains lead, is contained in large steel buckets. The VSI noted spillage of dross and other unidentified materials in this area. PRC rated the potential for current releases from this area as low due to containment inside a building with concrete flooring, solid form of the dross after cooling, easy detection, and easy cleanup; no SV is recommended. (PRC 11Dec92 pp. 29-30, 99-100, 127).

### **3.2.3.1 TCE in Well GM-27S**

Intermediate aquifer well GM-27S is located offsite approximately 750 ft northwest of the North Plant within 100 feet of AK Steel lower aquifer supply well 38. GM-27S has exhibited the chlorinated solvent TCE in all samples collected since well installation in 1989. TCE concentrations obtained at least annually through April 2001 have ranged from 110 ug/l in June 1997 to 940 ug/l in March 1996 (Arcadis 06Feb98, pg. 1; OEPA 01Dec99 Att. 4c). From the data provided (Table 3-1) it appears that after an increase between October 1991 and July 1992, TCE concentrations have remained approximately stable in the intermediate aquifer at GM-27S.

In 1997-1998 AK Steel consultant Arcadis conducted an investigation of the TCE occurrence in GM-27S. The primary objective of the study was to determine whether the source of TCE observed at GM-27S was associated with AK Steel activities in the North Plant Area. The study consisted of installation of two monitoring wells, water level measurement and ground-water sampling at five wells, and data interpretation. (Arcadis 06Feb98).

In the vicinity of GM-27S the intermediate aquifer is the shallowest saturated unit (G&M May89 Table 1, App. A, B; OEPA 01Dec99 Att. 4c Fig. 2). Relying on inferred piezometric surfaces for June 1997 (annual synoptic Middletown Works water elevation survey) and November 1997 (measurements local to GM-27S), Arcadis concluded that in the vicinity of GM-27S ground water within the intermediate aquifer flows toward the south to southeast. This direction of flow is induced by pumping of nearby AK Steel lower aquifer supply wells and by hydraulic connectivity (leakage) between the intermediate aquifer and the lower aquifer. The existence of leakage is inferred, based on cones of depression in the intermediate aquifer generally mimicking those of the lower aquifer. The interpreted south to southeast flow direction applies only to 1989 and later because AK Steel revised its lower aquifer pumping schedule in 1989. However, relying on a G&M computer simulation of pre-1989 ground-water flow, Arcadis concluded that ground-water flow in the vicinity of GM-27S also flowed south to southeast prior to the 1989 pumping schedule changes. (Arcadis 06Feb98).

Historical and current south to southeast ground-water flow at GM-27S implies that ground water moves from offsite towards onsite through the well. Arcadis finds this to be "strong evidence that the source of TCE ? is not from main operations of the North Plant, and that the source is likely to the north, northwest, or possibly west of plant boundaries. Even under the assumption that groundwater flow patterns in the intermediate aquifer fluctuate from the use of other production wells in the North Plant Area, migration from the North Plant Unit is considered very unlikely, since no TCE was observed in monitoring wells located to the south and east of monitoring well GM-27S" (Arcadis 06Feb97 pg. 8).

## **Contaminants Released to Surface Water and Ground Water at AK Steel**

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Ground-water flow in the intermediate aquifer at GM-27S is inferred by AK Steel to be toward AK Steel. However, the 1997-1998 spill-specific investigation installed and sampled monitoring points based on this inference and failed to detect the TCE plume. That brings into question the inference that flow is from offsite to onsite. Moreover, there are several shortcomings to the study.

Well GM-27S is on the boundary of the AK Steel monitoring network, and no data have been collected to characterize the aquifer west, northwest, or north of GM-27S. Therefore interpretation of flow direction at GM-27S is speculative. In particular, absent water quality data in these directions from GM-27S it remains uncertain whether TCE actually is arriving from offsite.

The TCE-free samples purportedly downgradient of GM-27S are inconclusive because they are too shallow. Arcadis relies on wells A2I, GM-26S, A1I, and GM-06S to investigate the extent of the TCE plume downgradient of GM-27S within the intermediate aquifer. However, as indicated in Arcadis (06Feb98 Figs. 3, 4) and G&M (May89 App. A), GM-27S opens to a sand and gravel layer which is below a gravelly clay till, and wells A1I, GM-6S, and GM-26S are screened above this till in a shallower sand and gravel unit. Arcadis does not include A2I in a cross-section, but its depth and lithology suggest that it, too, is screened above the till (G&M May89 App. A; Arcadis 06Feb98 Att. A). Finally, well K—which is positioned directly “downgradient” of GM-27S and is screened in the same layer as GM-27S (as inferred in Arcadis 06Feb98 Figs. 1, 3, 5, 7)—was not sampled for TCE. <62>

AK Steel has not determined the source of TCE detected at GM-27S. It is only known that a subsurface plume of TCE—perhaps extensive—exists in a volume which includes the screened interval of GM-27S. Logged sediments indicate laterally continuous units of sand and gravel (e.g., Arcadis 06Feb98 Figs. 3, 4) which would be expected to convey dissolved TCE a considerable distance. TCE plumes in such materials may extend thousands of feet downgradient of source areas. The temporal persistence of the GM-27S plume, as measured by static or rising concentrations at GM-27S, implies that the source also persists—perhaps as spilled product (nonaqueous phase liquid, or “NAPL”) within the soil.

Typically a finding of several hundred ug/l TCE in ground water would lead to a more complete study than that of Arcadis (06Feb98). Such a study would review historical storage, transfer, and usage of TCE by facilities (including railroads and any sewers) in the upgradient direction(s). <63> Such a study would discuss whether, and if so where, TCE is used and transported at AK Steel. <64> Such a study also would include environmental sampling of various types in the inferred upgradient direction(s) from GM-27S. This sampling would be sufficient to define the upgradient extent of the plume and, hopefully, to locate the source. Finally, the study would add enough sampling locations to delineate the downgradient extent of the TCE plume. This would allow one to confirm or refute Arcadis's hypothesized fate of the TCE: entrainment into AK Steel production wells.

### **3.2.4 Coil Paint Area**

PRC (11Dec92) identifies six SWMUs in the Coil Paint Area. According to PRC, ground-water contamination within the Coil Paint Area suggests that releases have occurred in this area. Observed ground-water contaminants include carbon

## Contaminants Released to Surface Water and Ground Water at AK Steel

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disulfide, dichloromethane ("methylene chloride"), TCE, and 111TCA, of which all but 111TCA are RCRA hazardous constituents. (PRC 11Dec92 pg. 55; OEPA 01Dec99 Att. 4c). 111TCA may be a listed RCRA hazardous waste (F001, F002). To my knowledge detections of these solvents occurred before 1992—but I lack some years' data—and within the intermediate aquifer. No sources have yet been identified. Lacking indication of specific source(s), all six PR/VSI SWMUs (22 through 27) in the Coil Paint Area are described in the following paragraphs. Except for SWMU 23, all of the Coil Paint Area has been sold by AK Steel.

The **former Coil Paint WWTP** operated from 1978 to 1985. The WWTP is now reduced to a **surge tank (SWMU 22)** which feeds into the North Terminal Wastewater Treatment Facility. No specific releases have been identified from the former Coil Paint WWTP or the surge tank. PRC rated the potential for current releases from this area as low due to location within a building; no SV is recommended. (PRC 11Dec92, pp. 52-55, 56, 112, 136).

Three unlined **Former Coil Paint Wastewater Treatment Lagoons (SWMU 23)** received various solvents and metals (primarily hexavalent chromium) from 1971 to 1978. Two of the lagoons removed suspended solids from coil paint plant waste waters and the third dewatered the resultant sludge. The lagoons were backfilled in 1986; according to Armco some soil samples were taken. The area is now a fenced field. PRC rated the potential for current releases from this area as low-to-moderate due to on-the-one-hand backfilling but on-the-other-hand ignorance of closure details, absence of lining, and unavailability of reported soil sampling results; an SV is recommended. (PRC 11Dec92 pp. 55-56, 113, 137).

The **Former Hazardous Waste Storage Area (SWMU 24)** behind the Coil Paint building occupies the western half of an asphalt-paved surface. Through April 1988 SWMU 24 was used to store drums of hazardous waste including spent solvents (F003, F005) and possibly painting wastes (waste paint, EP toxic waste paint sludges). Product storage occurred on the eastern half of the paved surface. On March 9, 1987 OEPA observed evidence of a past spill at SWMU 24: gray paint on the asphalt with possible runoff to adjacent soil. Subsequent soil sampling by Armco detected leachable metals arsenic, selenium, cadmium, lead, barium, mercury, and hexavalent chromium, and organics n-butyl alcohol (may be F003), toluene (U220), xylenes (may be F003), 2-ethoxyethylacetate, and 2-butanone (a.k.a. "methyl ethyl ketone" or "MEK" [U159]). Contaminated soil was excavated in spring 1987. PRC rated the potential for current releases from this area as low, but acknowledged that past spills releases may have occurred. No SV is recommended, except that soils under asphalt should be sampled if asphalt is removed at a future date. (PRC 11Dec92 pp. 56-58, 113-114, 137).

The **Waste Solvent Accumulation Tank and Indoor Solvent Transfer Unit (SWMU 25)** collects waste solvent generated primarily from cleaning equipment and rollers used to apply paint to coils of steel. OEPA noted staining of two overlapping colors on the tank side in November 1989. According to Armco two overfill incidents occurred as follows. In summer 1988 an overflow alarm malfunctioned and about 20 gallons of solvent waste spilled into the secondary containment area. It was contained and cleaned up. In June 1989 during a maintenance operation about 1 pound of solvent waste spilled onto the concrete pad beyond the secondary containment. It was immediately cleaned up. PRC rated the potential for current releases from this area as low due to very small

## **Contaminants Released to Surface Water and Ground Water at AK Steel**

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releases, effective past cleanups, and recent preventative measures; no SV is recommended. (PRC 11Dec92 pp. 60-61, 114, 138).

A converted trailer body, the **Container Accumulation Shed (SWMU 26)**, houses stored non-liquid wastes (e.g., lined cardboard containers of solvent rags and other items used for cleaning the coil paint area). There is no indication that liquid wastes were stored here. PRC rated the potential for current releases from this area as low due to the solid phase of the wastes, absence of stains, and generally well-managed appearance; no SV is recommended. (PRC 11Dec92 pp. 61-62, 114-115, 138).

A single 55-gallon drum with temporary lid, the **Satellite Accumulation Area (SWMU 27)**, sits on a concrete floor and is used to collect used rags, papers, and other items from its immediate area. In the VSI minor paint stains were observed on the drum and adjacent wall; these were inferred not to represent routine releases. The underlying floor was not significantly stained. PRC rated the potential for current releases from this area as low due to the paved building and minimal waste volume; no SV is recommended. (PRC 11Dec92 pp. 62-63, 139).

There is no discussion of the fabricating facility or the tubing facility in the PR/VSI (PRC (11Dec92); in particular no SWMUs are identified in those areas.

### **3.2.5 Slag, Mill Scale, and Waste Processing Area**

The shoe-shaped portion of AK Steel property south of Oxford Road and East of Yankee Road contains slag and mill scale processing facilities and various waste management units (landfills). G&M refers to this entire area as the "Slag Processing Area" (OEPA 01Dec99 Fig. 2).

**Preamble on PCBs.** Most of the environmental data collected within the Slag Processing Area pertains to PCBs within the OMS Area. PCBs are environmentally persistent and of concern at very low concentrations. The Ohio Water Quality Standards for PCBs are 0.00079 ug/l for human health 30-day average, 0.0017 ug/l for outside mixing zone 30-day average and 0.0 ug/l for drinking water (OEPA 01Mar01; <http://www.epa.state.oh.us/dsw/rules/01-34.pdf>).

OEPA detected PCBs in Dick's Creek sediments in 1995 and in Monroe Ditch drainage waters and an apparently culpable east bank seep in November 1997. In early December 1997 OEPA required AK Steel to address the seep contamination. (Arcadis 08Feb02 Sect. 2.4). A series of field investigations have ensued, a number of PCB releases within the Slag Processing Area have been identified, and two interim remedies have been implemented (Arcadis 08Feb02 Table 1). Currently, by my count, at least eight discrete releases of PCBs within the Slag Processing Area have been recognized. They are described in indented Sections 3.2.5.1 through 3.2.5.8 below.

In the Slag Processing Area PCBs have migrated through the perched and upper aquifers. Typically, PCBs mobility is expected to be low in ground-water systems. However, "due to slag and mill scale properties, such as the lack of clay minerals [which sorb PCBs], low organic content [organics also sorb PCBs], and high permeability zones, PCBs have migrated horizontally in solution with water or attached to particles (such as mill scale fines) which migrate via the coarser

## Contaminants Released to Surface Water and Ground Water at AK Steel

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perched zone" (Arcadis 15Jul99 pg. 33). Migration through the upper aquifer is not as easily attributed to exceptional site conditions, but clearly it has been occurring as well.

**Arcadis Reports Inconsistencies.** There are many inconsistencies in reported chemical results and in mapped sampling locations and other plant features among the various Arcadis reports on the Slag Processing Area. I have noted some of these matters in footnotes in this section.

I also note that Arcadis (08Feb02) has inflated the total PCBs concentration for every soil and water sample analyzed for PCBs homologues, if at least one homologue was detected. This is done both for the 1998 and the 2001 samples. In each such case Arcadis has assumed that non-detected homologues in the sample actually were present at 0.5 times the reporting limit, and has increased the calculated total PCBs accordingly. This is evident from Arcadis (08Feb02 pg. 67) and from inspection of Arcadis (08Feb02 Table K-2) for soils and Arcadis (08Feb02 Table K-6) for water. The inflated results are propagated into the Arcadis (08Feb02) main text, figures, and tables. The inflated totals are in some cases several times larger than the total of detected homologue concentrations. Although they clearly err on the side of caution, and may therefore be useful for risk assessment calculation purposes, these calculated totals are otherwise rather misleading. Furthermore, one must ask why it is appropriate to make such an adjustment for the PCBs homologue analyses but not to do likewise for the much more numerous PCBs Aroclor analyses.

In this report, where I mention a total PCBs concentration based on a homologues analysis, the reported total is of detected homologues only. I have marked each such value by an asterisk.

Should these matters subsequently be clarified, I may revise my opinions accordingly.

**High pH, Colloids, and Correlation to PCBs in OMS Area Ground water.** PCBs concentration in OMS Area ground-water samples appears to be correlated to high pH (above pH=9)<sup><65></sup> and to the presence of colloidal matter<sup><66></sup> or other filterable suspended particles (Arcadis 08Feb02 Sects. 6.2.1, 9.5). The high pH in Slag Processing Area ground waters is caused by exposure to slag, which contains lime and other oxides. Arcadis suggests that colloids are associated with elevated pH and that they facilitate PCBs transport (Arcadis 08Feb02 pg. 89). Arcadis does not explain how or why Site colloids, or transport by colloids, are affected by pH.<sup><67></sup> Arcadis claims that a comparison of filtered and unfiltered samples from three wells demonstrates that "PCB detections in groundwater are related to suspended particulates and/or colloids in the OMS Area groundwater" (Arcadis 08Feb02 pp. 75-76). Arcadis does not include the relevant filtered sample results in its report.<sup><68></sup> Currently the pH-PCBs and colloids-PCBs relationships remain interesting but of uncertain predictive or practical value, and they are not discussed further in this report.

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**Non-landfill Facilities.** Most of the non-landfill facilities in the Slag Processing Area are located in its northwestern portion. These include maintenance, administrative, lab, and air compressor buildings; three mill scale processing

## **Contaminants Released to Surface Water and Ground Water at AK Steel**

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areas; the "Bone Yard" in Mill Scale Area 3; and the kish pot area. None of these facilities was designated as a numbered SWMU by the PR/VSI.

The **air compressor building** was built some time prior to 1973. It is constructed primarily of metal and has a cement floor. In the late 1990s a 55-gallon drum containing air compressor oil was found in the building, oil was noted on the floor, and the floor was noted to have visible cracks. (Arcadis 15Jul99 pg. 9).

An **oil storage area** exists immediately west of the maintenance garage. In the late 1990s approximately 1250 gallons of oil was being stored in five tanks located above ground in the rear of a semi-tractor trailer. (The oil is used for lubricating mobile equipment). Scrap oil was stored in 55-gallon drums at the same location awaiting off-site shipment. Dark oil-stained soils were present in the vicinity of the trailer and drums. (Arcadis 15Jul99 pg. 10).

An **air dump area** exists north of the oil storage and maintenance garage areas. As of the late 1990s AK Steel was hauling hot material from the BOF rubble pit to this area by truck, dumping it, allowing it to cool, and if possible then recycling it. The material sometimes was oily. (Arcadis 15Jul99 pg. 10).

There are seven **mineral oil electrical transformers** within the OMS Area. According to AK Steel none of them currently contains PCBs (Arcadis 15Jul99 pg. 12) and none of them ever did (Frost & Jacobs 03Dec99 pg. 3). Transformer locations are shown in Arcadis (15Jul99 Fig. 2). Environmental sampling data imply that PCBs were released at the locations of two of the transformers, as described in the following two sections.

### **3.2.5.1 Concrete-pad Mounted Transformer PCBs**

An electrical transformer is located between Mill Scale Areas 1 and 2 in the north-central OMS Area on a concrete pad beneath a conveyor system. According to Arcadis (08Feb02 pg. 23) this area is known as the Finished Slag Area. Figure 3-8 provides a map of sampling station locations within the OMS Area. In December 1997 PCBs were detected in soil adjacent to the transformer pad from 0-2 ft bgs (0.98 mg/kg) and from 2.5-3 ft bgs (1.66 mg/kg) (Arcadis 15Jul99 pp. 12, 13, Table 3). An October 1998 soil sample "CPMT" from 0-2 ft bgs contained 0.0099\* mg/kg PCBs (Arcadis 15Jul99 pp. 13-14, Fig. 4, Table 7; Arcadis 08Feb02 Table K-2).<sup><69></sup>

On June 29, 1998 boring BH22 was completed on the east or southeast side of the transformer pad; this location was selected "due to accessibility" (Arcadis 15Jul99 pg. 13, Fig. 4). At BH22 soil samples from 0-2 ft, 6-8 ft, and 9-10 ft bgs did not contain PCBs (Arcadis 15Jul99 Table 8).<sup><70></sup> Monitoring well MDA22P was installed in boring BH22. With respect to ground-water flow, the east side of the concrete pad is upgradient or side-gradient of the transformer (Arcadis 08Feb02 Fig. 18) and therefore is not necessarily in the path of contamination released from the transformer. Indeed, Arcadis (15Jul99 pg. 14) apparently uses MDA22P to represent "the perched zone upgradient from the conveyor pad-mounted transformer". No PCBs were detected in two water samples from MDA22P collected in June/July 1998 (Aroclor PCBs) and November 1998 (PCB homologues) (Arcadis 15Jul99 pg. 13, Figs. 4, 7, Tables 7, 9).<sup><71></sup> Two more recent water samples from replacement well MDA22PR (the original well could not

## **Contaminants Released to Surface Water and Ground Water at AK Steel**

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be found) reportedly contained 2.2P ug/l (all Aroclor 1242) in October 2001 and 0.56\* ug/l in December 2001 (Arcadis 08Feb02 pg. 36, Tables K-5, K-6). The precise location of MDA22PR with respect to the transformer has not been provided. (The initial boring for MDA22PR could not be completed due to shallow refusal). (Arcadis 08Feb02 pp. 28, 30).

In summary, PCBs have been released to the soils and perched ground water beneath and adjacent to the concrete-pad mounted transformer.

### **3.2.5.2 Pole-mounted Transformer PCBs**

A pole-mounted transformer is located near the center of the conveyor system, in the Finished Slag Area, about 300 ft southeast of the transformer discussed in Section 3.2.5.1 (Arcadis 08Feb02 Fig. 32, samples SS05 and CPMT). A surface soil sample (SS05) in June 1998 detected 0.94 ug/kg PCBs in the 0-0.5 ft bgs interval and no PCBs in the 1-2 ft interval (Arcadis 15Jul99 pg. 13, Table 6). No borings or wells have been installed in this vicinity and no additional soil samples have been collected.

In summary, PCBs have been released to the soil beneath the pole-mounted transformer, and no follow-up sampling has been conducted.

Historically, mill scale generally was managed in distinct areas in the central to eastern end of the OMS Area. The three current **mill scale areas** contain piles of mill scale whose location and size change almost daily. It is believed that PCBs were released to the environment in PCB-laden oils on stockpiled mill scale. Releases to current Mill Scale Areas 2 and 3 are described in two following sections. I am not aware of any sampling effort that targeted former mill scale storage areas, nor whether those locations are known.

### **3.2.5.3 Mill Scale Area 2 PCBs**

During 1998 soil samples were collected within Mill Scale Area 2 at borings BH03 through BH06 and BH26SL (Arcadis 15Jul99 Sects. 3.8.2, 4.3.2, Figs. 3, 4, 5, Tables 7, 8). PCBs were detected within the fill at 6-8 ft bgs in BH04 (4.60 mg/kg) and BH05 (0.884J mg/kg) and at 12 ft in BH26SL (0.244 mg/kg).<sup><72></sup>,<sup><73></sup> A perched water sample from boring BH05 did not contain PCBs (Arcadis 15Jul99 pg. 18, Table 9). Well MDA03P installed in boring BH03 contained 0.63 ug/l PCBs in June 1998 and no detectable PCBs in August 2001 (Arcadis 15Jul99 Table 9, Arcadis 08Feb02 Table 16).<sup><74></sup> (Section 3.1.2.5; Arcadis 15Jul99 pg. 15; Arcadis 16Mar01 pg. 5).

In summary, PCBs have been released to the fill and to the perched ground water within Mill Scale Area 2.

An unspecified number of **Former Ponds within Mill Scale Area 2** near to the Monroe Ditch seep area existed during 1980, and perhaps earlier, and may have persisted through 1986 or 1987. The ponds covered much of current Mill Scale Area 2: their extent apparently is indicated by dashed lines in Arcadis (15Jul99, Fig. 2). The origins—natural or anthropogenic—and functions of the ponds reportedly are unknown to AK Steel. The ponds are said to have been high in lime

## **Contaminants Released to Surface Water and Ground Water at AK Steel**

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content. (Arcadis 15Jul99 Sect. 3.9, Fig. 2; Arcadis 16Mar01 pg. 12).

### **3.2.5.4 Mill Scale Area 3 and Landfill SWMU 40 PCBs**

The boundary of Mill Scale Area 3 is rendered inconsistently in Arcadis (08Feb02) compared to earlier Arcadis documents (Arcadis 15Jul99, Arcadis 16Mar01). It appears that the latest document has mistaken the Bone Yard for Mill Scale Area 3. In the discussions below I presume that the earlier renditions apply.

Field investigations of Mill Scale Area 3 have relied in part on outside borings BH07 and BH08 and wells MDA08P/S located "just west of Mill Scale Area 3 and the Bone Yard" (Arcadis 15Jul99 pg. 19). However, BH08 is within closed landfill SWMU 40 (Arcadis 08Feb02 pp. 90-91) and BH07 appears to be so as well (Arcadis 15Jul99 Figs. 4, 5; Arcadis 08Feb02 Figs. 4, 7, 9). In any case, the two borings are not in Mill Scale Area 3 as currently mapped. Therefore the soil samples from these stations reflect contamination released at SWMU 40 (or wherever they are) rather than Mill Scale Area 3.

MDA08P and MDA08S are wells installed at the location of boring BH08. Arcadis' inferred ground-water flow direction implies that well MDA08P intercepts perched water from both the northern edge of the Mill Scale Area 3 and from SWMU 40. On the other hand Arcadis' inferred ground-water flow directions imply that well MDA08S is too far north to encounter upper aquifer ground waters affected by Mill Scale Area 3, although this is not conclusive.<sup><75></sup> (Arcadis 08Feb02 Figs. 16-19, 21-24).

Given the ambiguity of the Arcadis reports, rather than try to draw a distinction between SWMU 40 and Mill Scale Area 3 I have lumped them together for the time being as a single joint source Mill Scale Area 3/SWMU 40.

During 1998 soil samples were collected at borings BH07 (SWMU 40?), BH08 (SWMU 40?), BH10 (northern Mill Scale Area 3), BH11 (Bone Yard), BH12 (southern Mill Scale Area 3), and BH13 (eastern Mill Scale Area 3) (Arcadis 15Jul99 Sect. 3.8.3, Figs. 3, 4, 5, Tables 8, 9). PCBs were detected at 6-8 ft bgs in BH07 (9.95J mg/kg) and BH08 (288 mg/kg), and at 6-8 ft bgs in BH13 (8.04 mg/kg).<sup><76></sup>, <sup><77></sup> During 2001 ten additional borings were installed and sampled at four depths; six were located in or adjacent to SWMU 40 around BH07 and BH08; four were located around BH13 in eastern Mill Scale Area 3. PCBs were detected at all three loci in 29 of those 40 samples, with a maximum concentration of 25.6 mg/kg and three other results above 10 mg/kg. (Arcadis 08Feb02 pg. 29, Tables K-1, K-5).

Arcadis (15Jul99 pp. 33-34) reasons that the absence of PCBs in surface materials within the Mill Scale Areas "suggest[s] that these areas are historical sources, and are no longer active sources". As described above, subsequent surface soil sampling around BH08 and BH13 has detected PCBs. This presumably suggests the opposite: that these areas are active sources.

Grab water samples were collected from the perched zone at all of the 1998 borings except BH08; and PCBs were detected in BH07 (22.0J ug/l), BH11 (1.82 ug/l), BH12 (2.88 ug/l) and BH13 (49.4 ug/l). At BH08, perched zone monitoring well MDA08P was installed; water samples contained 13.1 ug/l and 3.05\* ug/l in

## Contaminants Released to Surface Water and Ground Water at AK Steel

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1998 and no detectable PCBs in 2000 and 2001 (Arcadis 15Jul99 Figs. 4, 7, Tables 7, 9; Arcadis 08Feb02 Tables 16, K-5, K-6).<sup><78></sup> Upper aquifer monitoring well MDA08S also was installed at the same location; water samples contained 0.73 ug/l and 0.25 ug/l in 1998 and no detectable PCBs in 2000 and 2001 (Arcadis 15Jul99 Figs. 4, 8, Tables 7, 9; Arcadis 08Feb02 Table K-5).

In summary, PCBs have been released to the fill and to the perched ground water within Mill Scale Area 3/SWMU 40. PCBs also have reached the upper aquifer in this vicinity, although it is unclear whether those PCBs originated in Mill Scale Area 3/SWMU 40.

The **Bone Yard** was located in the southwestern part of current Mill Scale Area 3, and in the preceding section it is discussed in conjunction with Mill Scale Area 3 as a source of PCBs. At one time the Bone Yard was used to store mill scale. Later it became a general storage area for unused equipment and materials removed from the Slag Processing Plant. This was its function when it was inspected by Arcadis some time during 1997-1999 and found to contain wooden wire spools, machinery, and empty tanks. As described in 2001, the Bone Yard was by that time covered with approximately 20 feet of mill scale, steel, slag and other debris, and processing equipment was installed at the surface of the slag pile. (Arcadis 15Jul99, pp. 17, 20; Arcadis 16Mar01 pg. 7).

The current **blast furnace slag processing area** is located south of SWMU 42 (Frost & Jacobs 03Dec99 pg. 7, Appendix K). No additional information has been obtained concerning activities in this area. <sup><Additional info?></sup> Blast furnace slag has been analyzed at AK Steel and found to contain <sup><are these percentages?></sup> approximately 40% calcium oxide (lime), one third silicon dioxide, 10% magnesium oxide, 9% aluminum oxide, 1% iron oxide, 1% manganese oxide, and 0.4% potassium oxide (AK Steel 11Nov99).

**Landfills.** There are several solid waste and liquid waste disposal units within the Slag Processing Area. Only some of them are designated as numbered SWMUs by the PR/VSI.

The **Closed Solid Waste Landfill by Yankee Road and Dick's Creek (SWMU 38)** north of Monroe Ditch apparently served first in 1966 as a staging area for channelization of Dick's Creek. According to aerial photography solid wastes were not deposited until some time after 1973.<sup><79></sup> Wastes included construction debris and residual wastes from plant operations. The latter included blast furnace and BOF air pollution control dust scrubber sludges, and wastewater treatment sludges from the blast furnace, sinter plant, BOF, hot strip mill, north and south terminal treatment plants, and water softening plant (Frost & Jacobs 03Dec99 pg. 6; Arcadis 08Feb02 pg. 8). Some pits were dug in which to dispose of blast furnace wastes. The approximately 14-acre fill extends to the bank of Monroe Ditch and to the bank of the south flood plain of Dick's Creek. AK Steel reportedly has no reason to believe that PCBs were present in these wastes. The fill was closed in 1980 by regrading the surface and capping with two feet or more of compacted clay and a vegetated soil cover. PRC rated the potential for current releases from this area as high because the fill is unlined; an SV is recommended. (PRC 11Dec92 pp. 79-80, 121-122, 144; Arcadis 16Mar01 pg. 6).

## **Contaminants Released to Surface Water and Ground Water at AK Steel**

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Boring MDA36S, located in the NW corner of SMWU 38 near the junction of Monroe Ditch and Dick's Creek, detected PCBs at 4-6 ft (0.49 mg/kg) and 10-12 ft bgs (2.15 mg/kg) in unsaturated fill above the native clay (Arcadis 08Feb02 Figs. 7, 12, 33, 34, Table K-1). The boring was completed as a well open to the confined upper aquifer beneath the clay, sampled in October 2001, and contained no PCBs. To my knowledge AK Steel has not offered an explanation for the occurrence of PCBs in this area.

The **Closed CERCLA Notification Solid Waste Landfill (SWMU 39; Landfill 1; South Landfill)** southwest of Monroe Ditch began receiving wastes prior to 1973 (Arcadis 16Mar 01 pg. 6), or in 1965 (PRC 11Dec92 pp. 81, 122; Frost & Jacobs 03Dec 99 Appendix K). The approximately 31-acre fill extended to Monroe Ditch on the north and east, and to the Former Ponds West of Monroe Ditch on the west. Wastes were placed into open piles and excavated pits and have been variously characterized as slag, construction soil and rubble, trash, coal tar decanter sludge, wastewater treatment sludge, and other industrial chemicals (PRC 11Dec92); as trash, garbage, open hearth wastewater treatment sludges, tar decanter sludge (K087) and oily sludges (Frost & Jacobs 03Dec99); and as construction debris, tars and steel making sludge (Arcadis 16Mar01 pg. 6; Arcadis 08Feb02 pg. 8). Slag was added as a fill material and stabilizer. Some pits contained only tar wastes (PRC 11Dec92 pg. 81).

Oily wastes were burned in ponds located on the west side of this fill; these ponds, now called the Former Ponds West of Monroe Ditch, are described in a subsequent paragraph. AK Steel reportedly has no reason to believe that PCBs were present in these pond wastes. In order to close this fill in 1980 the ponds were first dewatered, and then waste was cut from high portions of the fill and deposited in the pond area. Some regrading also occurred along Monroe Ditch. Then the fill and pond area was covered with two or more feet of compacted clay and a vegetated soil cover. PRC rated the potential for current releases from SWMU 39 as high due to observed leachate seepage to Monroe Ditch and due to the absence of a liner; an SV is recommended.

(PRC 11Dec92 pp. 122, 145; Frost & Jacobs 03Dec99 pg. 6; Arcadis 16Mar01 pg. 6).

Two discrete releases of PCBs from SWMU 39 have been identified; they are described in the next two sections.

### **3.2.5.5 Northwest Corner SWMU 39 (South Landfill) PCBs**

Seeps #11 and #12 are located adjacent to one another along the south bank of Monroe Ditch at the northwest corner of SWMU 39 near well MDA35SR (Arcadis 08Feb02 Fig. 46). Both seeps were found to be flowing twice during February 2001 and were dry during subsequent inspections. Sampled with duplicates on February 9, 2001, the seeps contained 5.47 to 10.2 ug/l total PCBs (all Aroclor 1242). Soil boring MDA35S or MDA35SR also contained PCBs at depth intervals 0-2 ft, 6-8 ft, and 10-12 ft, with a maximum concentration of 25.4 mg/kg total PCBs (17 mg/kg Aroclor 1242) in the 6-8 ft bgs sample. These samples were taken from above the fill-native clay contact in the interval where seepage flow would be generated.<sup><80></sup> Well MDA35SR did not contain PCBs in its water sample, but it is screened below a layer of clay in "a saturated native sand unit"

## **Contaminants Released to Surface Water and Ground Water at AK Steel**

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and therefore may be insulated from the surface and from Monroe Ditch (Arcadis 08Feb02 pp. 35, 91, 92, Tables 18, K-10, Figs. 8, 32, 33, 34).

South Landfill wastes are described in Section 3.2.5. The presence of PCBs at this landfill on the west side of Monroe Ditch has not been explained by any of AK Steel's theories of PCB releases at the Site.

In late 2002 AK Steel constructed a passive remedial system within the bank of Monroe Creek at the location of these seeps. The system consists of a sheet pile barrier along the creek and an upgradient sandwich of peat moss between layers of geotextile (K. Hileman 21May03 during site visit).

In summary, PCBs have been released to soils at the NW edge of SWMU 39 (South Landfill) and to shallow ground water and seeps emanating from SWMU 39 and discharging to Monroe Ditch.

### **3.2.5.6 East Side SWMU 39 (South Landfill) PCBs**

There is evidence that PCBs have been released along the east side of SWMU 39 (South Landfill). PCBs have been detected at well MDA33S and in certain west bank seeps and soils.

Well MDA33S, installed in October 2001, is located near the base of the east flank of SWMU 39 (South Landfill), adjacent to the west bank of Monroe Ditch and opposite the southwest corner of Mill Scale Area 2. The single water sample collected from MDA33S contained 2.9J total PCBs (all Aroclor 1248), which is one of the higher concentrations detected during the 2001-2002 Soil and Groundwater Investigation. (Arcadis 08Feb02 Tables K-5, K-6).

Although classified as an upper aquifer well by Arcadis (08Feb02), MDA33S actually opens to fill including slag, subtended by native clay and does not penetrate the upper aquifer (Arcadis 08Feb02 pg. 35, Table 2, Apps. F, G).<sup><81></sup> In the vicinity of MDA33S Monroe Ditch is incised into the hydrostratigraphic unit tapped by MDA33S, and ground water flows toward the Ditch (Arcadis 08Feb02 Fig. 24).

Shortly after sampling, MDA33S was found to contain an approximately three inch thick layer of dense nonaqueous phase liquid ("DNAPL"). Apparently this DNAPL was not sampled. Therefore it is not known whether the DNAPL is related to the release of PCBs or, indeed, of any other hazardous waste or constituent. However, it is notable that the water sample from MDA33S did contain seven PAHs including the highest detected concentrations of naphthalene (310D ug/l) and fluorene (25 ug/l) from the 2001-2002 study.

Seep SD10-SEEP on the western bank of Monroe Ditch, opposite the east bank "seep area" and the interception trench, was sampled in June or July 1998 and found to contain 21J ug/l PCBs. Sediments apparently from beneath the seep contained 4.36J and 1.93J mg/kg PCBs at depths 0-2 ft and 2-4 ft bgs, respectively. And soil from approximately 15 ft west of the seep, at 8-10 ft bgs (near Monroe Ditch water level), contained 0.869 mg/kg PCBs (SD10SL15W). Although Arcadis argues that these west side PCBs may have migrated over from the east bank and penetrated 15 ft into the native soils during high stream stage,

## **Contaminants Released to Surface Water and Ground Water at AK Steel**

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the simpler explanation is that PCBs exist within the landfill. (Arcadis 15Jul99 pp. 22-23, Fig. 7, Tables 9, 11).

South Landfill wastes are described in Section 3.2.5. The presence of PCBs at the landfill on the west side of Monroe Ditch is not explained by any of AK Steel's theories of PCB releases at the Site.

(Arcadis 08Feb02 pp. 75, 76, 90, Tables 2, 16, K-5, Figs. 24, 43).

In summary, PCBs have been released to the shallow ground water at the eastern edge of SWMU 39 (South Landfill) adjacent to Monroe Ditch, and ground water in this unit and location is expected to discharge to Monroe Ditch. DNAPL exists in this area, and in the ground water certain PAHs are elevated. Analyses of other organic chemical fractions (e.g., volatiles, semi-volatiles), which may be present in the DNAPL or ground water, have not been conducted.

The **Former Ponds West of Monroe Ditch** were first identified from a 1968 aerial photo. The ponds' influent is uncertain but believed to have been from tank, vat, or sump cleaning operations. These ponds also reportedly functioned by separating out solids and oil, with water overflow and periodic reclamation of oil. In addition, Armco burned oily wastes in the ponds. Approximately 10 ponds are visible in a 1973 aerial photograph, three additional ponds appear in a 1976 photo, and four more ponds appear in a 1980 photo. The USGS Trenton quad, its revisions based on 1978 aerial photographs and other sources, indicates that 22 distinguishable ponds were present. (PRC 11Dec92 pp. 81, 122; Arcadis 16Mar01 pp. 5, 11-12; Arcadis 08Feb02 Figs. A7, A8, A9).

In 1980 wastewater and sediment were sampled from the Former Ponds West of Monroe Ditch in anticipation of closure. Documentation of these events was destroyed by the steel plant. It is reported that no PCBs were detected in samples from the ponds. As mentioned above, the ponds were closed in 1980 by dewatering, removing oil and water for off-site recycling, and backfilling with redistributed landfill waste. The ponds, being incorporated into the closure of SWMU 39, ultimately were covered with two feet or more of compacted clay and vegetated soil cover. (Arcadis 16Mar01 pp. 5-6).

The **Closed Solid Waste Landfill (SWMU 40, Landfill 2)** is located between Mill Scale Area 3 and Monroe Ditch. It operated from the mid-1960s until 1980. Wastes have been characterized as construction rubble and soils, trash, and possibly wastewater treatment sludges (PRC 11Dec92), solid waste (Arcadis 16Mar01), and tar decanter sludge (Frost & Jacobs 03Dec99). Wastes were placed into open piles and into excavated pits. During 1980-1981 the approximately 3-acre fill was capped with two feet of low permeability soil and seeded. Slag processing is conducted immediately north of the landfill. PRC rated the potential for current releases from this area as high due to the absence of a liner; an SV is recommended. (PRC 11Dec92 pp. 82-83, 123, 145; Frost & Jacobs 03Dec99 pg. 6; Arcadis 16Mar01 pg. 7; Arcadis 08Feb02 Fig. 4). SWMU 40 is discussed in Section 3.2.5.4 as a joint source of PCBs with Mill Scale Area 3.

The **Closed Solid Waste Landfill West of Slag Processing Area Access Road and South of Dick's Creek (SWMU 41, Landfills 4 and 5)** operated some time during 1965-1980, but the precise period is unknown. The SWMU consists of two or

## **Contaminants Released to Surface Water and Ground Water at AK Steel**

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three cells occupying approximately 14 acres. The fill contains mostly sludges from the BOF, South Terminal, and Hot Strip Mill wastewater treatment plants (PRC 11Dec92); or dust from the blast furnace and BOF and wastewater sludges from the blast furnace, sinter plant, BOF, Hot Strip Mill, North and South Terminal wastewater treatment plants, and water softening plant (Frost & Jacobs 03Dec99). Wastes were placed into open piles and into excavated pits. During 1980-1981 this SWMU was capped with two feet of compacted low permeability soil and the cover was seeded. PRC rated the potential for current releases from this area as high due to observed seepage toward Dick's Creek and due to the absence of a liner; an SV is recommended. (PRC 11Dec92 pp. 83-84, 123-124, 146, Fig. 5; Frost & Jacobs 03Dec99 pg. 6).

**The Closed (1989-1990) Solid Waste Landfill East of Slag Processing Area Access Road and South of Dick's Creek (SWMU 42, Landfill 6)** operated from an unknown date (PRC 11Dec92 pg. 84) or the early 1980s (PRC 11Dec92 pg. 124) to 1990.<sup><82></sup> The approximately 20-acre fill consists of two rectangular trenches bisected by a railroad track. The fill received sludges and dusts from air pollution control equipment and wastewater treatment sludges from various wastewater plants (PRC 11Dec92); or dust from the blast furnace and BOF and wastewater sludges from the blast furnace, sinter plant, BOF, Hot Strip Mill, North and South Terminal wastewater treatment plants, and water softening plant (Frost & Jacobs 03Dec99). Wastes arrived by rail and were covered daily with soil. PRC rated the potential for current releases from this area as high due to the absence of a liner, and also expressed concern that the fill is located adjacent to a boggy area abutting Dick's Creek; an SV is recommended. (PRC 11Dec92 pp. 124-125, 146; Frost & Jacobs 03Dec99 pg. 6).

**The Active Solid Waste Landfill (SWMU 43, Landfill 7)** south of Dick's Creek was so named because it was operating during the PR/VSI in 1991 (11Dec92 Sect. 4.5.6). It was still active in late 1999 (Frost & Jacobs 03Dec 99), but Arcadis (16Mar01 Fig. 2) indicates that the fill was later closed. The approximately 28-acre fill (in 1991) received wastewater treatment plant sludges (PRC 11Dec92), or dust from the blast furnace and BOF and wastewater sludges from the blast furnace, sinter plant, BOF, Hot Strip Mill, North and South Terminal wastewater treatment plants, and water softening plant (Frost & Jacobs 03Dec99). Wastes arrived by rail and were covered with soil daily. PRC rated the potential for current releases from this area as high due to the absence of a liner; an SV is recommended. (PRC 11Dec92 pp. 125, 147; Frost & Jacobs 03Dec99 pg. 6).

**The Former Oil Separator Ponds** were first identified from a 1966 aerial photo of the site. The three large and two small rectangular ponds received influent of uncertain origin, but it is thought to have been from tank, vat or sump cleaning operations. Solids and oils, if present, settled out, water overflowed to surface drainage, and oils were periodically reclaimed. During periods of high precipitation it is possible that oil also overflowed to surface drainages; the most likely such pathway is a former drainage path to the west along the north side of the railroad tracks. (Arcadis 15Jul99 pp. 14, 15-16, Fig. 2; Arcadis 16Mar01 pg. 5). The practice of gravity separating waste oils at the ponds was terminated in 1974 with construction of the No. 4 Oil Recovery Plant (Frost & Jacobs 03Dec99 pg. 3).

## **Contaminants Released to Surface Water and Ground Water at AK Steel**

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In addition to the five rectangular Former Oil Separator Ponds, several (at least three) circular ponds existed immediately to the north; their functions are not described in available documents (Arcadis 15Jul99 Fig. 3; Arcadis 16Mar01 App. D Fig. 3; Arcadis 08Feb02 pg. 21).

In 1980 wastewater and sediment were sampled from the Former Oil Separator Ponds in anticipation of closure. It is unclear to me whether sampling included the circular ponds as well as the small rectangular ponds. Documentation of these events was destroyed by the steel plant. It is reported that PCBs were detected in samples from the three larger ponds but not in those from smaller ponds. PCB-free ponds were closed in 1980 by dewatering, removing oil and water for off-site recycling, and backfilling with clean fill. (Arcadis 16Mar01 pp. 5-6).

Closure of the three larger Former Oil Separator Ponds, which did contain detected PCBs, was delayed until 1983. At that time Armco contractor CECOS removed PCB-containing liquids, excavated sludge until PCBs were non-detectable, and backfilled the excavation with brick and rubble (construction and demolition debris) and capped with at least two feet of native clay. The area currently is a grass-covered mound. (Arcadis 15Jul99 pg. 14; Frost & Jacobs 03Dec99 pg. 4). The excavated PCB-contaminated wastes were "managed in accordance with Toxic Substances Control Act (TSCA) requirements". (Arcadis 16Mar01 pg. 6). Subsequent sampling has demonstrated that PCBs were released to the soil and ground water, as described in the next section. In addition, Arcadis believes that periodic overflows from the ponds deposited PCBs in downstream areas labeled "Former Drainage Paths"; this is discussed in Section 3.2.5.8.

### **3.2.5.7 Former Oil Separator Ponds PCBs**

In 1998 soils surrounding the Former Oil Separator Ponds were investigated using four borings (BH14 through BH17), each sampled at 0-2 ft and 6-8 ft bgs within slag fill and (except BH16) at 10-12 ft bgs in native sandy silt and clay; all samples were above the saturated zone. Only BH15, located approximately 40 ft north of the westernmost large pond, contained PCBs: Aroclor 1248 was detected at 1.86 mg/kg and 1.20 mg/kg in the deeper two samples. A PCBs homologue sample from the BH15 detected 98.4 mg/kg PCBs, which is one of the highest results at the Site. In 2000-2001 eight additional borings were completed in the general vicinity of the ponds, including one boring within the footprint of each of the three larger ponds.<sup><83></sup> Except for the two borings around the compressor building 200+ ft northwest of the ponds, all borings detected PCBs. The highest concentrations, up to 49 mg/kg, were found not within a pond footprint, but (again) in BH15-satellite borings up to approximately 150 ft north of the westernmost pond. To my knowledge AK Steel has not offered an explanation for the occurrence and concentration of PCBs in soils to the north of the large ponds.

Monitoring wells were installed in all four 1998 borings, and water samples in 1998 and 2000-2001 did not contain PCBs. Similarly, new well MDA32S installed within the footprint of the westernmost large pond contained no PCBs in 2001. Four of the five wells in the ponds vicinity (except MDA15S) are open to the so-called shallow groundwater zone, which is a laterally discontinuous shallow hydrostratigraphic unit above the upper aquifer. The perched unit is not present in this area.

## **Contaminants Released to Surface Water and Ground Water at AK Steel**

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(Arcadis 15Jul99 Sect. 3.6, Tables 7, 8; Arcadis 16Mar01 App. E; Arcadis 08Feb02 pp. 29-30, 57, Fig. 43, Tables 2, K-1, K-5).

In summary, PCBs have been released to the soils beneath and in the vicinity of the Former Oil Separator Ponds. The highest detected concentrations occur north of the westernmost pond. PCBs have not been detected in ground-water samples from the uppermost saturated unit in this vicinity.

### **3.2.5.8 Former Drainage Swale PCBs**

In 1999 Arcadis conjectured that periodic overflows from the Former Oil Separator Ponds deposited PCB-laden oils along a downstream surface-drainage swale. Arcadis labels the swale Former Drainage Path and Former Drainage Swale. The swale extended south from the westernmost Former Oil Separator Pond, then turned west and meandered along the north side of elevated railroad tracks to Monroe Ditch. Currently the pathway contains a filled gravel parking lot and areas of vegetation. Ponding of surface water within the vegetated areas during precipitation has been observed. (Arcadis 15Jul99 pg. 15, Fig. 3; Arcadis 16Mar01 pp. 19-20).

In 1998 17 borings (15 soil-only borings and two completed as wells MDA25P and MDA09P) were sampled to examine the PCBs distribution in soils along and adjacent to this swale. In 2001 five additional borings were completed. PCBs were detected in surface and subsurface soils along an approximately 1000 ft central segment of the swale from station SS01-E680 to station SS03. The highest concentrations, 39 mg/kg at 0-2 ft bgs and 78.7 mg/kg at 2-4 ft bgs, were found about halfway down the swale at station SS01. Apparently no PCBs were found in boring BH09 near Monroe Ditch. <84>

Ground-water monitoring stations exist near the halfway point (MDA25P, GM35S) and near the Monroe Ditch terminus (MDA09S/P) of the swale. MDA25P, screened in the perched aquifer, contained PCBs (19.5J ug/l) in 1998 and no detectable PCBs in 2000 and 2001. Adjacent upper aquifer well GM35S also contained PCBs (0.58J ug/l) in 1998 and none in 2000 and 2001. Perched unit well MDA09P and upper aquifer well MDA09S have not detected PCBs.

(Arcadis 15Jul99 Sect. 3.7, pp. 28-30, Figs. 6, 7, 8, Table 9; Arcadis 08Feb02 pp. 29, Table K-5).

A theory is advanced in Arcadis (15Jul99) that perched ground water flow may convey PCBs from the contaminated central segment of the swale towards the seeps area of Monroe Ditch. <85> The proposed sinuous subsurface pathway follows a depression in the buried surface of the native clay labeled Flowpath 1 (which extends from Former Drainage Path, through Mill Scale Area 3, to Mill Scale Area 2) and Flowpath 2 (which extends from Mill Scale Area 2 to Monroe Ditch seeps). A buried "levee-like high" subsurface ridge in the clay is shown running parallel to Monroe Ditch south of the seeps area; Arcadis claims that this feature diverts perched ground water northward, preventing its discharge to the Ditch south of the seeps area. (Arcadis 15Jul99 Sect. 4.1, Fig. 14).

However, Arcadis (08Feb02) has substantially revised the interpreted top-of-clay topography, although without comment. There is no longer a levee-like high, and

## **Contaminants Released to Surface Water and Ground Water at AK Steel**

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the depression in native clay beneath the swale now continues due west to the bank of Monroe Ditch (Arcadis 02Feb02, Sect. 4.1.1, Figs. 6, 7, 14).<sup><86></sup> In addition, the direction of perched ground-water flow beneath the swale is now inferred by Arcadis to proceed generally south-southwest beneath the elevated railroad tracks (Arcadis 08Feb02 Figs. 16-19). It appears that Arcadis no longer has any reason to argue that PCBs within the Former Drainage Swale make their way to the Monroe Ditch "seeps area". Rather, the fate of those PCBs remains unexplored.<sup><87></sup>, <sup><88></sup>

In summary, PCBs have been released along the Former Drainage Swale to underlying soils, perched ground water and upper aquifer ground water. Overflow of PCB-contaminated oils from the Former Oil Separator Ponds is a likely source of the PCBs. Contamination is highest about midway along the swale, and none has been detected near the swale junction with Monroe Ditch. Ground-water flow proceeds south-southwest from the contaminated area; migration of PCBs in that direction has not been explored.

The **kish pot area** is site of a drenching platform for water-quenching of steel slag for cooling and watering of kish pots for dust control. As discussed in Section 2.3.2, water-quenching operated between April 1997 and early 2000. The discharged water presumably entered the perched aquifer system. An indoor kish air-cooling operation replaced water cooling in about February 2000; that system also uses a large quantity of water. (Arcadis 15Jul99, pp. ES-2, 35; Frost & Jacobs 03Dec99 pg. 5; USEPA 17Aug00 para. 20; Arcadis 16Mar01, pg. 30).

The **B-Scrap Area** is south of Dick's Creek immediately to the west of SWMU 41, and the **Blast Furnace Slag Processing Area** is south of the middle two Dick's Creek landfills. (Arcadis 1999?). I have not been provided descriptions of these areas.<Additional info?>

### **3.2.5.9 Monroe Ditch and Dick's Creek PCBs**

Unlike the other sections in this chapter, this section does not examine a source which has released hazardous constituents from AK Steel to the environment. Rather, this section discusses the interface where previously released hazardous constituents move from the subsurface back to the surface. This reemergence occurs where contaminated ground water discharges onto the banks (as visible seeps) or into the channels (as submerged seepage) of Monroe Ditch and Dick's Creek. Although these water bodies are merely way stations along the migration pathways of released substances at AK Steel, they have both regulatory and remedial significance at the Site.

The two creeks have been the subject of regulatory attention since OEPA's November 1997 discovery of PCBs in Monroe Ditch. Activities now are guided in large part by an Administrative Order to AK Steel (USEPA 17Aug00).

Thus far AK Steel has taken an onsite-containment approach to remediation: PCBs are to be prevented from leaving the Slag Processing Area, and the exits are to be monitored. Containment and exit monitoring measures are discussed below. Apparently no effort is being made to remediate PCB sources within the AK Steel property.

## Contaminants Released to Surface Water and Ground Water at AK Steel

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**Containment measures.** In November and December 1997 PCBs were detected in seeps along the eastern bank of a segment of Monroe Ditch labeled the "seep area" (Arcadis 15Jul99 pg. 21). During 1998 an interception trench was installed parallel to the seep area to capture contaminated perched and upper aquifer ground waters flowing toward that portion of the Ditch. Subsequent to a trench extension later in 1998, no seepage has been observed entering the Ditch in the seep area.

Beginning in November 2000, AK Steel reportedly has been inspecting the banks of Monroe Ditch and Dick's Creek for seeps every two weeks (Arcadis 08Feb02 pg. 77). Thirty-six seeps have been identified so far; in most months one or more new seeps are discovered (Arcadis 08Feb02 Table 18). In general the seeps flow intermittently: the majority have been present on only a single occasion (Arcadis 08Feb02 pg. 91). Each seep has been sampled once for PCBs (Arcadis 08Feb02 Tables 18, 19, K-10), and four of the seeps have been found to contain PCBs.

Two of the contaminated seeps (#11, #12, PCBs 5.47 to 10.2 ug/l) are located on the south bank of Monroe Ditch at the NW corner of SWMU 39 (South Landfill). They were observed to be flowing twice in February 2001 and have since been dry through October 2001 (Arcadis 08Feb02 pp. 78, 91, Tables 18, K-10). A passive barrier remedy has been installed in that area (Section 3.2.5.5).

The other two PCB-contaminated seeps (#10, #22, PCBs 0.58 to 1.4 ug/l) are located on the south bank of Dick's Creek between wells MDA29S and MDA27S and have been flowing during several of the monthly inspections; seep #22 has been present at every inspection beginning in July 2001. PCBs also have been detected in the nearby upper aquifer wells MDA27S (0.23\* ug/l) and GM46SR (1.60\* ug/l).<sup><89></sup> (Arcadis 08Feb02 Sect. 9.5.2, Tables K-5, K-6). AK Steel reportedly is proceeding with a passive interception remedy within the floodplain of Dick's Creek. (Arcadis 08Feb02, pp. 78, 88, 91, 92, Table K-10).

**Exit monitoring measures.** Beginning in 4<sup>th</sup> quarter 1998 AK Steel began monthly grab sampling of channel waters at two locations in Dick's Creek: the confluence with Monroe Ditch, and near Yankee Road Bridge (Arcadis 08Feb02 pp. 46, 47; Arcadis 10Mar99, Arcadis 29Apr99, Arcadis 20Jul99, Arcadis 27Oct00 Table 2; Arcadis 08Feb02 pg. 77, Tables 18, 19). No PCBs have been detected in those samples through September 2000 (latest data I have).

The exit monitoring measures do not appear to recognize or detect contaminated ground water which may enter Monroe Ditch or Dick's Creek below the stream water surface. In both channels the upper aquifer discharges at least in part through the saturated stream bed. Except for the estimate of 50 gpm total seepage inflow to Monroe Creek in the seeps area before construction of the interception trench (Arcadis 15Jul99 pg. 20), I have found no field data (e.g., stream segment water balances; seepage meters) concerning rate of seepage inflow to the creeks below the water line. To my understanding submerged seepage is not identified or sampled by the periodic seeps inspection program, except in bulk at the "exit" by the two monthly surface water grab samples. An Arcadis estimate of PCBs loading to Dick's Creek (Arcadis 08Feb02 Sect. 9.5.2) likewise ignores contributions entering below the water line.

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## Contaminants Released to Surface Water and Ground Water at AK Steel

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In addition, the exit monitoring measures apparently do not assess migration of contaminated stream sediments. Because PCBs partition strongly to particulates, it is expected that almost all migration of PCBs within the surface water channels will occur via moving particulates, including both suspended particles and those tumbling along the streambed ("bedflow"). Particle migration within streams is extremely episodic, often with nearly all mass transport accomplished during stormflow. The particles which make up the creeks' sediment are mobile. "Dick's Creek and vicinity tributaries generally contain a high proportion of sand-size and greater material" (Arcadis 15Jul99 pg 24), but silt and clay content also are significant. <90>, <91>

In particular, PCBs attached to sediments within Monroe Ditch migrate offsite during storms, and PCBs on sediments within Dick's Creek—already offsite—are carried downstream during storms. Sediment sampling data indicate that PCBs from the Slag Processing Area have contaminated sediments within both surface water bodies—upstream background sampling locations are PCB-free—and that high levels of PCBs have been conveyed along Dick's Creek at least 1.6 miles downstream of the mouth of Monroe Ditch. In fact, the highest two PCBs sediment concentrations of the OEPA 1995 Great Miami River basin survey were obtained at

→ Dick's Creek RM 2.51 (183 mg/kg) <92> and RM 0.93 (143 mg/kg). Arcadis also has detected PCBs in sediments from Dick's Creek 1.5 miles downstream of the mouth of Monroe Ditch. (OEPA 30Dec97 pg. 202; Arcadis 15Jul99 Sect. 3.11; Fig. 9; Arcadis 08Feb02 Sect. 2.6.4). <93>

Finally, it follows from the episodic, sediment-driven nature of PCBs migration within stream channels that the monthly surface water grab samples are not sufficient to measure PCBs exiting the Site. Except fortuitously, such samples are not collected during potentially significant transport events. Even during a storm event a water sample does not detect transport by bedflow and does not appropriately weight transport by various particle-size fractions.

PCBs also likely migrate from the AK Steel vicinity by another mechanism: in the flesh of fish. PCBs have been detected in fish sampled from Dick's Creek (OEPA 30Dec97 pg. 206, Table App. A-8).

In summary, AK Steel is pursuing a PCBs-containment remedy in the OMS Area. A Monroe Creek interception trench apparently has eliminated seepage to the Ditch above the water line in its vicinity. Passive interception remedies are installed adjacent to another segment of Monroe Ditch and planned for a segment of Dick's Creek. The "exit monitoring" strategy in the OMS Area relies solely on above-water level seep inspections and sampling to detect PCBs escaping from the AK Steel property. No effort is made to assess PCBs discharged into stream channels below the water line. No effort is made to assess PCBs transported by sediment migration, which typically peaks during storm events.

### 3.2.5.10 Unidentified Sources

**PCBs.** A number of discrete PCBs sources within the Slag Processing Area have been identified and are described above in Sections 3.2.5.1 through 3.2.5.8. However, PCB contamination detected at the seeps described in Section 3.2.5.9 implies that the picture is not yet complete.

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The PCBs originally detected in Monroe Ditch and now captured by the interception trench once were attributed by Arcadis to a serpentine surface and subsurface flow path originating at the Former Oil Separator Ponds, with secondary contributions from Mill Scale Area 2 (Section 3.2.5.8). Current understanding of perched aquifer flow indicates that PCBs from the Former Oil Separator Ponds (no perched aquifer) and Former Drainage Swale (south-southwest ground-water flow) do not migrate in the perched aquifer towards the seeps area of Monroe Ditch. Thus at this time the source of the PCBs intercepted at the trench is not known with specificity. At best one can speculate that mill scale, in current Mill Scale Area 2 and/or in formerly used storage areas, may be responsible.

A second unidentified source is responsible for the PCBs detected in seeps #10 and #22 and upper aquifer wells GM46SR and MDA27S along Dick's Creek. This contamination is not attributed to any of the sources identified by AK Steel or listed in Sections 3.2.5.1 through 3.2.5.8. USEPA has stated that the source should be found and, if necessary, removed (USEPA 02Jul01 pg. 2).<sup><94></sup>

It is significant that PCBs have migrated through upper aquifer sands and through fluvial sediments before arriving at the seeps along Dick's Creek. Both of these natural geologic media would *a priori* be expected to greatly impede migration of PCBs; yet apparently they do not. PCBs are mobile through the upper aquifer, as well as the slag, at this Site.

**Metals.** Recent samples from most seeps within the OMS Area have not exhibited metals concentrations exceeding the current Ohio Voluntary Action Program generic unrestricted potable use standards ("VAP standards")<sup><95></sup> (Arcadis 08Feb02 App. K). However, elevated metals, some of them exceeding the VAP standards, were detected in a string of three neighboring seeps #16 (03/21/01), #17 (03/21/01), and #18 (04/19/01) located along Dick's Creek north to northwest of the B-Scrap Area (Arcadis 08Feb02 Fig. 46). All three contained lead in excess of the 15 ug/l VAP standard (189 ug/l, 119 ug/l and 102 ug/l respectively). Total chromium also was detected in all three seeps at 102 ug/l, 50 ug/l and 63 ug/l, respectively; the VAP standard is 100 ug/l. Mercury was present in Seep #16 (0.3 ug/l). Although the mercury VAP standard is 2 ug/l, this detection is notable for its uniqueness—no other mercury detection is reported for seeps sampled in the 2001 field program. The proximity of these three metals-enriched seeps suggests that the detections reflect an area where metals mobility is enhanced, perhaps by anomalous pH conditions. Further investigation would be required to assess the extent and significance of these findings.

Arcadis recently collected filtered samples of ground water from wells within the OMS Area. Metals concentrations in filtered samples typically is interpreted to reflect the mobile fraction of metals within ground water. Comparatively higher concentrations in unfiltered samples are attributed to particulates which are stirred up within the well by sampling but which would not migrate through the ground-water system. However, as discussed elsewhere concerning PCBs, the very coarse-grained, slag, perched aquifer at the Site permits migration of particulate matter. Therefore it remains an open question whether metals-bearing particulates also can migrate with ground water through the perched system in the OMS Area.

## **Contaminants Released to Surface Water and Ground Water at AK Steel**

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The filtered ground-water sample results from 1998 and 2001 indicate that Arcadis detected no metals concentrations exceeding VAP standards (Arcadis 08Feb02 Table K-8). Even so, well MDA-23P, located east of the Monroe Ditch interception trench, was notable for having the highest dissolved chromium on both dates (36 ug/l and 60 ug/l; VAP standard is 100 ug/l).<sup><96></sup> These results suggests that the well is in an area where metals mobility is enhanced, perhaps by anomalous pH conditions. Further investigation would be required to assess the extent and significance of these findings.

### **General.**

Past practices at AK Steel apparently placed little or no emphasis on preventing infiltration of spills into the ground. Treatment lagoons and spill containment ponds and channels typically were not lined. A spill which did infiltrate into the ground generally received no further attention beyond surface cleanup; in particular no ground-water sampling was performed.<sup><97></sup> Some contamination of ground water is likely as a result of these practices, and the degree of that contamination remains a matter of speculation until sufficient exploratory monitoring is conducted.

### **3.2.6 NPDES Outfalls**

There are five external NPDES outfalls from AK Steel into Great Miami River (one), Dick's Creek (three), and North Branch Dick's Creek (one).<sup><98></sup> These outfalls carry stormwater runoff and treated liquid wastes from AK Steel to the streams. Upon occasion spilled hazardous wastes and hazardous constituents have escaped through these outfalls to the receiving water bodies.

OEPA Pollution Incident Reports ("PIRs") filed by AK Steel between November 1988 - January 1998 document multiple instances of spills to Dick's Creek and the Great Miami River through these outfalls (as well as additional spills to land) (OEPA 24Jun03; Ohio Attorney General 25Feb00; OEPA 01Dec99 Att. 3b). With some overlap, OEPA (01Dec99 Att. 5d) also tabulates AK Steel NPDES permit violations between February 1992 - June 1999 for the five outfalls. Some of the spills consisted of or contained listed hazardous wastes including spent pickle liquor (K062); other spilled hazardous wastes include flushing liquor (fish kill resulted), the microbiocide bis (tributyltin) oxide (fish kill resulted), and untreated acids. Spilled listed hazardous constituents include cyanide (P030), benzene (U019), naphthalene (U165), phenolics (likely including phenol [U188] and 2,4-dimethylphenol [U101]), toluene (U220), lead, selenium, and paint solvent waste.

The great bulk of the 136 NPDES permit violations (including both external outfalls and internal monitoring stations) reported by AK Steel to OEPA between 1990-1995 concerned the following regulated parameters: ammonia, free cyanide, phenol, nickel, zinc, total suspended solids, and flow. OEPA Emergency Response spill records from 1978 to 1991 include 58 spills from AK Steel to the Great Miami River or Dick's Creek. The Ohio Dept. of Natural Resources records for 1965 to 1991 include 18 fish kills believed to have been caused by the AK Steel facility. (OEPA 30Dec97 pp. 84, 114).

In addition to PIRs describing spilled hazardous wastes and constituents and the

## **Contaminants Released to Surface Water and Ground Water at AK Steel**

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few samples taken in conjunction with spills, environmental sampling data is available to characterize the receiving water bodies. In summer 1995—as part of an extensive survey of the middle to lower Great Miami River basin—OEPA conducted surface water, sediment, and fish tissue sampling, and biological habitat, macroinvertebrate, and fish species surveys in nearby Great Miami River, Dick's Creek, and North Branch Dick's Creek (OEPA 30Dec97). Some results from these studies are described in the following sections.

### **3.2.6.1 Great Miami River**

The Great Miami River flows south along a sinuous course several thousand feet west of the Site and receives discharges from AK Steel outfall 011 at river mile ("RM")<sup><99></sup> 51.4. Outfall 011 consists of effluents from the North Terminal WWTP, blast furnace/sinter plant WWTP, non-contact cooling water, and stormwater runoff; average discharge in 1995 was 7.73 MGD. (OEPA 30Dec97 pg. 30).

In the OEPA 1995 survey, surface water (daytime grab) samples from Great Miami River downstream of AK Steel NPDES outfall 011 detected ammonia at consistently elevated levels with some exceedances of water quality criteria.

Sediment samples downstream of the outfall (and downstream of the Middletown combined sewer outfalls) contained the highest concentrations from the entire OEPA 1995 survey for arsenic, barium, cadmium, chromium, copper, iron, lead and mercury. Excepting barium, all of these metals plus zinc were ranked as extremely elevated and/or at severe effect levels.<sup><100></sup> Numerous polycyclic aromatic hydrocarbons ("PAHs") also were found, with anthracene and fluorene exceeding the severe effect level. All 17 PAHs detected at RM 51.3 downstream of outfall 011 were at the highest observed concentrations of the OEPA 1995 survey; many of these compounds are RCRA listed hazardous constituents.

Macroinvertebrate community performance was significantly impacted by the discharge from outfall 011. Organism density dropped remarkably between the upstream station (RM 51.5) and downstream station (RM 51.3). Within the outfall mixing zone (RM 51.4) macroinvertebrate indices were poor, indicative of highly toxic conditions, and an oily sheen was released from the substrate when disturbed. A decline in fish community performance from full-attainment upstream to non-attainment downstream coincided with the zone of degraded sediment quality; other likely contributing causes include poor quality effluent, poor quality habitat, and impacts from the Middletown combined sewer outfalls.

(OEPA 30Dec97 pp. 15, 16, 30, 125, 183, 199-200, 222-223).

### **3.2.6.2 Dick's Creek**

Dick's Creek flows from east to west through the Site north of the Slag Processing Area and south of Oxford Road. The creek receives discharges from (upstream to downstream) AK Steel NPDES outfalls 015, 003, and 002 at RM 4.15, 3.80, and 2.92, respectively. Outfall 015 consists of Hot Strip Mill clarification effluent, non-contact cooling water, and stormwater runoff (1995 avg. 0.651 MGD). During low flow conditions Dick's Creek typically is dry upstream of the confluence with North Branch Dick's Creek, although water from North Branch backs up some way into Dick's Creek. Moraine Materials, a manufacturer of ready-mix concrete, is

## **Contaminants Released to Surface Water and Ground Water at AK Steel**

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located on Dick's Creek upstream of North Branch. For an uncertain period prior to July 1995, washout from that facility entered the Dick's Creek channel from storm drains; concrete and, apparently, lime were dumped into the stream bed. Outfall 003 consists of treated BOF effluent, cooling tower blowdown, and stormwater runoff (1995 avg. 1.12 MGD).<sup><101></sup> Outfall 002 consists of untreated coke plant cooling water and stormwater runoff (1995 avg. 0.794 MGD). (OEPA 30Dec97 pp. 31, 160, 229).

In the OEPA 1995 survey, surface water (daytime grab) samples from Dick's Creek contained grossly elevated, acutely toxic levels of ammonia. These samples happened to be collected shortly after a July 26, 1995 flushing liquor spill from AK Steel outfall 003 to Dick's Creek that resulted in a massive fish kill.<sup><102></sup> In addition to the spill-related samples, other Dick's Creek water samples on occasion exceeded criteria for lead, zinc, selenium, and several organochlorine pesticides<sup><103></sup> and were elevated for total cyanide.

Sediments from Dick's Creek contained highly or extremely elevated metals cadmium, chromium, nickel, and zinc. (Some of these exceedances, including the peak nickel concentration and high arsenic, chromium and zinc levels, occurred at RM 5.21 which is upstream of the AK Steel outfalls and North Branch, and downstream of Moraine Materials). PCBs were found in Dick's Creek at extremely elevated levels (above the severe effect level)—the highest of the OEPA 1995 survey. PAHs also were detected, with up to nine compounds at a station, all exceeding criteria.

The contaminated sediments corresponded spatially with a significant impairment (poor and very poor quality) of macroinvertebrate community performance and fish community in Dick's Creek. The poor macroinvertebrate community performance in Dick's Creek from RM 4.7 to RM 2.6 is attributed to toxic instream conditions created by AK Steel discharges (OEPA 30Dec97 pg. 229). All sampled segments of Dick's Creek were in non-attainment of designated use criteria.<sup><104></sup> In comparison to a 1987 survey these 1995 aquatic life indices had declined, in contrast to an improving trend observed in many other Ohio rivers and streams.

(OEPA 30Dec97 pp. 15, 16-17, 19, 32, 159-162, 186, 202, 229, 266, 284, Fig. 66).

### **3.2.6.3 North Branch Dick's Creek**

The tributary North Branch Dick's Creek flows along the eastern boundary of the Site and receives discharges from outfall 004 at RM 0.22. It empties into Dick's Creek at the latter's RM 5.11. Outfall 004 consists of effluents from South Terminal WWTP, the EGL WWTP, non-contact cooling water, and stormwater runoff (total 2.175 MGD). (OEPA 30Dec97 pp. 31, 162).

An April 1997 spill of SPL apparently is an example of AK Steel ignorance concerning features of its physical plant, with ensuing impact on the environment. On April 21<sup>st</sup> AK Steel reported a 500 gallon SPL spill to soil with all released liquid fully contained onsite. On April 22<sup>nd</sup> portions of North Branch Dick's Creek and Dick's Creek were found to be orange throughout the water column, with orange-coated vegetation and sediments. The responding OEPA OSC estimated

## **Contaminants Released to Surface Water and Ground Water at AK Steel**

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that over 2.5 stream miles were discolored. Upon reinspecting its onsite containment area, AK Steel determined that the spill had not been kept onsite, but in fact had entered an unnoticed pipe leading to a ditch which discharges to NPDES outfall #004 on North Branch Dick's Creek.

In the OEPA 1995 survey, surface water (daytime grab) samples from North Branch Dick's Creek downstream of AK Steel outfall 004 had consistently elevated conductivities and dissolved solids, the highest zinc concentration (795 ug/l) of the entire OEPA 1995 survey, selenium and three organochlorine pesticides above the water quality criteria, and elevated nickel.

Sediments from North Branch Dick's Creek downstream of AK Steel outfall 004 contained highly elevated zinc and highly elevated dieldrin (a pesticide).

The contaminated sediments corresponded with a significant impairment of macroinvertebrate community performance indicative of a toxic response. Fish community indices did not indicate impairment. All sampled segments of North Branch Dick's Creek were in non-attainment of designated use criteria.

(OEPA 30Dec97 pp. 17, 19, 30-31, 162, 187, Table A-6).

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## **4.0 DISCUSSION AND OPINIONS**

The objective of this report (transcribed from Section 1) is to form and document an expert opinion on the following issues:

- (1) What hazardous wastes, and hazardous constituents have industrial operations at the Site released to on-Site soil, surface water, or ground water?
- (2) What released hazardous wastes and hazardous constituents have migrated—or will migrate—off-Site in the surface water or ground water?

In this section I address each of these issues in turn by stating my opinions and then providing supporting facts and reasoning. Unless stated otherwise, in the following sections “releases” refer to releases of hazardous wastes and/or hazardous constituents as they are defined in Section 1.

### **4.1 Releases to Onsite Environmental Media**

Polychlorinated biphenyls (“PCBs”) have been released to the soil and ground water at multiple locations within the Slag Processing Area (Sections 3.2.5.1 through 3.2.5.8). PCBs have migrated with shallow ground water, discharged in seeps to Monroe Ditch and Dick's Creek (Section 3.2.5.9), and contaminated water and sediments within Monroe Ditch and Dick's Creek (Section 3.2.5.9). Investigations conducted at the Slag Processing Area to identify and locate PCBs sources have not determined the sources of PCBs in seepage to Monroe Ditch and Dick's Creek. (Section 3.2.5.10). The PCBs remedy at the Slag Processing Area is a containment remedy: no effort is being made to remediate the sources within the Slag Processing Area. This containment remedy requires continuous vigilance due to frequent emergence (or discovery) of new seeps. The detection program does not monitor for PCBs entering the stream channels below the water line or for sediment-borne PCBs migrating downstream during stormflow; therefore PCBs may be escaping offsite/downstream undetected through these mechanisms. (Section 3.2.5.9).

From 1983 to 1990 AK Steel sprayed coal tar decanter tank sludge (K087) onto coal resting on bare soil at the Robin Hood (K-087 sprayed) Coal Storage Pile (SWMU 17). This longstanding practice likely released the hazardous waste to soil. Infiltration by the liquid waste and by leachate from the pile may have conveyed hazardous constituents to the underlying ground water. Contamination from stored tar, coal and other materials within the broader materials storage area contributes to soil contamination and masks particular contributions by K087 waste (Section 3.2.1.4).

As described in Section 3.2.1.4, other stored materials have a similar chemical profile to K087 waste. This confounded AK Steel's attempt to identify K087 waste in the soils beneath the former coal pile.

No samples of ground water were collected beneath or in the vicinity of the Robin Hood Coal pile. Therefore no information is available concerning the quality of ground water beneath or downgradient of the coal pile.

The upper aquifer is believed to be present beneath the Robin Hood Coal Storage Pile (G&M May89 Figs. 27, 30; OEPA 01Dec99 Att. 4c; CCA 19May00 Fig. 2).

## **Contaminants Released to Surface Water and Ground Water at AK Steel**

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Borings to 20 ft bgs during the closure study did not encounter saturated conditions, but an upper aquifer water table may have been below that level. Ground-water flow in the upper aquifer is not captured by the lower aquifer supply wells (G&M 06Nov92, pg. 3) and is believed to proceed broadly southwest from SWMU 17 toward Dick's Creek and the community of Oneida (OEPA 01Dec99 Att. 4c). Moreover, the intermediate aquifer is expected to be present at about 50 ft bgs in this area (CCA 20Nov98). If the intermediate aquifer is the uppermost saturated unit, then infiltrating contamination may directly degrade that aquifer.

Given the high concentrations of multiple coal and coal product constituents found in soils beneath the broader coal pile storage area, I conclude that from an environmental perspective the Robin Hood Coal Pile investigation, excavation, and ensuing closure was only a gesture. It confirmed but did nothing significant to improve widespread soil contamination from coal and coal derivatives, and did nothing to explore possible ground-water contamination, within the materials storage area. <105>

The 1996 COG pipeline leak released hazardous constituents including BTEX to soils and ground water in the western Melt Area (Section 3.2.1.1). Soil remediation ended in 1998. The zone of capture of the installed extraction wells was not resolved. Seven years later, ground-water cleanup is continuing in the northern, more contaminated, portion of the plume. In the southern portion of the plume where cleanup was thought to be complete and no remedy is active, benzene has recently been detected once again. The full extent of the plume has not been determined.

Delineation of the downgradient extent of the COG spill ground-water plume is incomplete. Contaminated ground water may have migrated into the Oneida community beyond the reach of the remedial systems.

The coal tar/benzene leak in the southwest corner of the Melt Area was discovered in 1989 but is of unconfirmed origin and unknown—perhaps multi-decade—duration. The suspected source is associated with two coal tar storage tanks installed in 1952 (AOC 2). The leak released hazardous constituents to the soil and ground water in the southwestern Melt Area. Benzene is the principal detected contaminant (Section 3.2.1.2); however, ground-water samples have not been analyzed for semi-volatile constituents of coal tar which also may be present. No source investigation or source cleanup has been undertaken. Downgradient offsite plume boundaries to the west (private property) and south (Dick's Creek) have not been delineated.

Although AK Steel believes that released coal tar is responsible for the plume, ground-water samples associated with the coal tar/benzene investigation have not been analyzed for semi-volatile organic compounds present in coal tar. The major constituents of AK Steel coal tar are listed in Cox-Colvin & Associates, Inc. (19May00 Table 1), and include the semi-volatile compounds phenol, methylphenols (cresols), and naphthalene (among others), all of which can be mobile in ground water.

During the 1990s and early 2000s onsite ground-water concentrations of benzene at coal tar/benzene leak monitoring wells have declined to nondetectable levels. This is encouraging news, but again samples were not quantitated for

## **Contaminants Released to Surface Water and Ground Water at AK Steel**

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semi-volatile organic compounds, and the off-site extent of the plume remains uncharacterized.

The hydrogeologic setting beneath AK Steel is conducive to relatively rapid, unhindered migration of ground water and dissolved contaminants.

Ground-water flow within the coarse-grained aquifers beneath AK Steel is relatively rapid. Such geological deposits generally do not substantially retard (by sorption) migration of contaminants dissolved in the ground water.

The environmental sampling program at AK Steel has been and continues to be inadequate to detect existing or new releases to soil and ground water. Available soil and ground-water data generally are too sparse to discover spills, except by chance.

Apparently no synoptic soil sampling or soil gas sampling is, or ever has been, performed at the facility.

It is telling that of the four studied ground water contaminant plumes at AK Steel (Section 4.1.1), two completely escaped detection by any pre-existing monitoring well (COG fuel in Melt Area, PCBs in Slag Processing Area<sup><106></sup>), and the other two each affected only one monitoring well (coal tar/benzene in Melt Area: well GM-4S; TCE in North Plant: well GM-27S). This illustrates that the existing monitoring well density is inadequate for detection of current or new ground-water contamination at the facility.

With very few exceptions, no soil or ground-water sampling program monitors or has monitored for releases from the USEPA-identified solid waste management units (SWMUs) at AK Steel.

USEPA's Preliminary Review/Visual Site Inspection in 1991-92 identifies a number of SWMUs which displayed evidence of past releases, or where the current likelihood of releases was greater than "low", or where further sampling (an SV) was recommended (see Section 3.2). A USEPA corrective action stabilization questionnaire echoes the SV recommendations for further investigation (USEPA 12Jun92 Sect. 18). With few exceptions, these potential release sites have not been investigated by soil or ground-water sampling.

The existing ground-water monitoring network at AK Steel was designed prior to the PR/VSI; therefore it does not target the SWMUs. Moreover, the wells themselves were designed as piezometers (water-level measuring devices) rather than as water quality monitoring wells, and thus may be inappropriate or unreliable for the latter purpose.

An OEPA compliance evaluation inspection in November 1996 reportedly found that runoff or wastewater generated from operating landfill and slag processing areas has discharged, perhaps over many years, to Dick's Creek (OAG 29Jan98 pg. 4). An AK Steel consultant determined that the active landfill is affecting underlying ground water quality and that the ground water drains to Dick's Creek. The impact of closed landfills, if any, has not been investigated. (OAG 19Mar97 p. 6-7; OAG 29Jan98 pg. 7). <what are the technical references for these statements by OAG?>

## **Contaminants Released to Surface Water and Ground Water at AK Steel**

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The AK Steel water supply extraction wells purportedly capture all intermediate and lower aquifer ground waters from beneath Middletown Works. However, since these wells are not sampled for hazardous wastes or hazardous constituents, even a successfully captured release would not be detected by them. Changes or abandonment of the system could release a heretofore contained plume.

AK Steel claims to have implemented a lower aquifer pumping scheme which captures all intermediate and lower aquifer ground water that passes beneath the property. I have not reviewed data demonstrating this capture and therefore reserve comment on the claim.

To my knowledge, individual extraction wells are not sampled and analyzed for hazardous wastes or hazardous constituents. Therefore, even if an old release—or a new concealed release such as an underground tank or pipeline leak—is being captured, it would not be detected. Detection is important not only to protect the water supply users, but also in case capture is partial, other risks are associated with the release, or changes in the extraction scheme might compromise full capture.

Should AK Steel cease or significantly alter pumpage, any currently captured—but unrecognized—plumes of contamination may quickly migrate to the extraction wells of downgradient water users within the highly permeable buried valley of the Great Miami River. For instance, the City of Middletown public water supply wellfield taps this aquifer to the north-northwest of AK Steel (OAG 19Mar97).

Within half of the Melt Area and all of the South Plant Area and Slag Processing Area releases from the surface to ground water will not be captured by the AK Steel water supply extraction system.

Within the south half of the Melt Area (including the Coke Plant) and all of the South Plant Area and Slag Processing Area the perched aquifer and/or the upper aquifer exist and would be first to receive substances released at the surface. AK Steel has concluded that its water supply extraction scheme does not capture ground water from these two aquifers.

Indeed, as noted in an opinion above, spills to these areas have migrated offsite, including the COG pipeline leak and the coal tar/benzene spill within the Melt Area, and PCBs released within the Slag Processing Area.

Soil and ground water have not been sampled at the flushing liquor spill sites, and therefore it is not known to what extent hazardous constituents were released to the soil and ground water by these spills.

Flushing liquor contains multiple hazardous constituents, of which many are quite soluble and mobile in ground water. I am unaware of any soil or ground-water sampling that examined the impact of flushing liquor spills at AK Steel. (Section 3.2.1.3).

The flushing liquor spills occurred in the vicinity of the Coke Plant. The upper aquifer is present beneath and in the vicinity of the Coke Plant (G&M May89 Figs. 27, 30; OEPA 01Dec99 Att. 4c). Ground-water flow in the upper aquifer is not

## **Contaminants Released to Surface Water and Ground Water at AK Steel**

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captured by the lower aquifer supply wells (G&M 06Nov92 pg. 3) and is believed to proceed south toward Dick's Creek and west toward the community of Oneida (OEPA 01Dec99 Att. 4c).

Diesel oil was released from a railroad tanker car between the Melt Area and the South Plant Area. It is likely that some oil penetrated to the ground water table, yet no ground-water sampling has been performed at the site of the spill. Additional investigatory work is necessary to determine whether, and if so to what degree, ground water has been impacted by that spill. (Section 3.2.1.5).

The hazardous constituent trichloroethene ("TCE") consistently has been detected (at 110 to 940 ug/l) in offsite intermediate aquifer monitoring well GM-27S. The source of TCE at GM-27S remains unidentified, and—except for GM-27S itself—the plume has not been delineated. Additional investigatory work is necessary to identify the source, the extent of the plume, and the direction of TCE migration. (Section 3.2.3.1).

Ground-water contamination in the Coil Paint Area suggests that releases have occurred in this area. Observed ground-water contaminants include carbon disulfide, dichloromethane ("methylene chloride"), TCE, and 111TCA. No investigation has been conducted. (Section 3.2.4). Investigatory work is necessary to assess the source(s) and severity of these releases.

Observed ground-water contamination in the Coil Paint Area—a particularly vulnerable area directly underlain by sand and gravel deposits—has not been investigated. Detected compounds include the hazardous constituents carbon disulfide, methylene chloride and TCE, all of which are solvents. 111TCA, also detected, may qualify as a RCRA hazardous waste (F001, F002). Monitoring wells are few and far between in the Coil Paint Area. It is not evident that ground-water samples were analyzed for paint solvent and paint waste compounds (which may be D001). The direction of intermediate aquifer ground-water flow in the Coil Paint Area is ambiguous; in particular it is not clear whether the flow is captured by lower aquifer extraction wells or continues offsite to the north (OEPA 01Dec99 Att. 4c Fig. 2).<sup><107></sup> In summary, Site data is not adequate to characterize the severity or fate of releases to soil and ground water within the Coil Paint Area.

Several open or closed landfills, most of which have been labeled as SWMUs, exist in the Slag Processing Area. The fills may contain hazardous wastes or hazardous constituents associated with disposed sludges, dusts, and oils, among other materials. The fills have been capped but are unlined and may generate leachate which enters underlying soils and shallow ground water. Investigatory work is required to determine whether the fills are releasing hazardous wastes or hazardous constituents.

Section 3.2.5 describes landfills identified within the Slag Processing Area as of the dates of the PR/VSI and subsequent PCB-related field studies. The SWMU landfills include two closed fills on opposite sides of Monroe Ditch (SWMU 38 north of the ditch, SWMU 39 southwest of the ditch); a small closed fill west of the Bone Yard (southwest of Mill Scale Area 3); a closed fill on the west bank of Monroe Ditch south of SWMU 39; and three closed fills along the south bank of Dick's Creek in the eastern half of the Slag Processing Area (SWMUs 41, 42, and 43). In some cases leachate has been observed draining from a fill (SWMU 39,

## **Contaminants Released to Surface Water and Ground Water at AK Steel**

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SWMU 41). "Preliminary soil and ground-water samples have revealed the presence of VOCs and heavy metals." (USEPA 12June92 Sect. 18). <108> PCBs have been detected in soils at the edge of some landfills (SWMU 38, SWMU 39, SWMU 40). DNAPL has been detected in a well adjacent to landfill SWMU 39, and ground-water contamination including PCBs and PAHs is high in that well (Section 3.2.5.6). At each of the SWMU landfills the PR/VSI rated the potential of current releases as high and recommended additional sampling (an SV).

An OEPA compliance evaluation inspection in November 1996 reportedly found that runoff or wastewater generated from operating landfill and slag processing areas has discharged, perhaps over many years, to Dick's Creek (OAG 29Jan98 pg. 4). An AK Steel consultant determined that the active landfill is affecting underlying ground water quality and that the ground water drains to Dick's Creek. The impact of closed landfills, if any, has not been investigated. (OAG 19Mar97 p. 6-7; OAG 29Jan98 pg. 7). <what are the technical references for these statements by the OAG? (this paragraph is a copy of an earlier one)>

Although substantial soil and ground-water sampling has occurred in response to PCB contamination within the Slag Processing Area, chemical analyses have been confined to PCBs, PAHs, certain metals, and general water quality parameters such as pH, temperature, and specific conductance. In particular the analyses have not included quantitation of volatile and most semivolatile organics and other hazardous constituents potentially released from landfilled wastes.

The complexity of site stratigraphy demands that individual spill sites receive individual geological investigations, which typically will include additional drilling, water level monitoring, and plume delineation in three dimensions.

### **4.2 Releases Known to Be Escaping Offsite**

Ground waters within the upper aquifer and perched aquifer ultimately flow offsite from the AK Steel property.

Within half of the Melt Area and all of the South Plant Area and Slag Processing Area the upper aquifer or the perched aquifer is the uppermost saturated zone and thus the first to receive any substances released to the surface. AK Steel has concluded that its water supply extraction scheme does not capture ground water from these two aquifers. Indeed, according to piezometric contour maps developed by AK Steel, flow in the perched and upper aquifers converges to Dick's Creek and Monroe Ditch (OEPA 01Dec99 Att. 4c; Arcadis 15Jul99 Figs. 15, 16; Arcadis 16Mar01 Figs. 9-15; Arcadis 08Feb02 pg. 6). Flow reaching Dick's Creek has left the AK Steel property: Dick's Creek runs along, but north of, the property line. Monroe Ditch—where it receives perched flow from AK Steel—is within the plant boundaries, but in short order it flows north, crosses the property boundary, and empties into Dick's Creek.

The perched aquifer and the upper aquifer convey released hazardous wastes and hazardous constituents offsite.

The three investigated spills to the perched and upper aquifers all have conveyed hazardous constituents offsite. The coal tar/benzene leak contaminated the upper aquifer, and benzene migrated offsite. (AK Steel purchased an adjacent

## **Contaminants Released to Surface Water and Ground Water at AK Steel**

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downgradient parcel; however, benzene was detected entirely across the newly acquired property, implying that the plume still extends offsite). The COG fuel pipeline leak contaminated the upper aquifer and benzene migrated offsite to adjacent residential property. PCBs releases in the Slag Processing Area entered the perched aquifer and the upper aquifer and migrated with ground water to onsite Monroe Ditch and then offsite with surface water and mobile sediments, and also migrated directly offsite with ground water to Dick's Creek.

Onsite spills of liquid hazardous wastes and hazardous constituents at AK Steel have escaped through NPDES outfalls, contaminating water and sediment and poisoning wildlife. In addition, effluent of plant wastes through the NPDES-permitted outfalls has degraded downstream water quality, sediment quality, and biological indicators in Dick's Creek and Great Miami River.

Section 3.2.6 describes the five offsite NPDES outfalls from AK Steel, spills of chemicals through the outfalls to receiving water bodies, fish kills, and elevated levels of chemicals and biological impact indices downstream of the outfalls. Some of the released substances, such as flushing liquor, are listed hazardous wastes or contain hazardous constituents. In addition high levels of other substances such as ammonia and zinc compounds appear to be correlated with impaired ecological health. Finally, the sharp decline observed in river health indices from upstream to downstream of AK Steel outfalls likely indicates that routine discharges from the facility are degrading North Branch Dick's Creek (Section 3.2.6.3), Dick's Creek (Section 3.2.6.2) and Great Miami River (Section 3.2.6.1).

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## **Contaminants Released to Surface Water and Ground Water at AK Steel**

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## **Contaminants Released to Surface Water and Ground Water at AK Steel**

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# Contaminants Released to Surface Water and Ground Water at AK Steel

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## TABLES

Table 1: Summary of Contaminant Release Data  
Table 2: Detailed Contaminant Release Data  
Table 3: Contaminant Release Data by Facility  
Table 4: Contaminant Release Data by Year  
Table 5: Contaminant Release Data by Medium  
Table 6: Contaminant Release Data by State  
Table 7: Contaminant Release Data by County  
Table 8: Contaminant Release Data by Census Tract  
Table 9: Contaminant Release Data by ZIP Code  
Table 10: Contaminant Release Data by Block Group  
Table 11: Contaminant Release Data by Tract Group  
Table 12: Contaminant Release Data by County Group  
Table 13: Contaminant Release Data by State Group  
Table 14: Contaminant Release Data by Region  
Table 15: Contaminant Release Data by Country  
Table 16: Contaminant Release Data by Continent  
Table 17: Contaminant Release Data by Hemisphere  
Table 18: Contaminant Release Data by Planet  
Table 19: Contaminant Release Data by Universe  
Table 20: Contaminant Release Data by Multiverse

## Contaminants Released to Surface Water and Ground Water at AK Steel

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Table 3-1. Trichloroethene in Intermediate Aquifer Well GM-27S

Date	TCE Concentration (ug/l)
1989	160
Mar, Jun, Sep 1990	250, 140, 130
April 1991	180
October 1991	170
July 1992	450
1993	*
1994	500
1995	480
March 1996	940
June 1997	110
November 1997	490
March 1998	500
March 1999	660
2000	*
April 2001	450

\*No data has been provided

1 From 1970 to April 1994 the Site was owned by Armco. "AK Steel" and "Site" are used in this report to refer to the steel plant without regard to date or ownership except where specifically stated otherwise. However, "Armco" is used in this report where appropriate to accurately transcribe passages from cited texts.

2 As defined in 42 U.S.C. § 6903 (5): "The term "hazardous waste" means a solid waste, or combination of solid wastes, which because of its quantity, concentration, or physical, chemical, or infectious characteristics may-- (A) cause, or significantly contribute to an increase in mortality or an increase in serious irreversible, or incapacitating reversible, illness; or (B) pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, or disposed of, or otherwise managed."

3 For the purposes of this report "hazardous waste" includes but is not limited to the "listed hazardous wastes" of 40 CFR Parts 261.31 (non-specific sources, F###) and 261.32 (specific sources, K###). Herein I highlight listed hazardous wastes by appending the EPA Hazardous Waste No. (e.g., coal tar decanter sludge [K087]).

4 A waste also can be classified as a RCRA hazardous waste by its exceeding standards of ignitability (D001), corrosivity (D002), reactivity (D003), or toxicity (D004 through D043, depending on which toxic contaminant exceeds limits when the waste is tested by the toxicity characteristic leaching procedure ["TCLP"]). Where I indicate these "D" codes for toxicity (e.g., chromium [D007]), it is understood that the presence of the toxic substance does not necessarily cause the waste to be hazardous: to be deemed a hazardous waste under the toxicity characteristic the waste must fail the TCLP criterion for that substance.

## **Contaminants Released to Surface Water and Ground Water at AK Steel**

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5 "Hazardous constituents" are tabulated in 40 CFR Part 261 Appendix 8, which can be found at [http://www.access.gpo.gov/nara/cfr/cfrhtml\\_00/Title\\_40/40cfr261\\_00.html](http://www.access.gpo.gov/nara/cfr/cfrhtml_00/Title_40/40cfr261_00.html). Herein I highlight listed RCRA hazardous constituents by appending the EPA Hazardous Waste No. (e.g., trichloroethene [U228]).

6 Solid Waste Management Units ("SWMUs") and Areas of Concern ("AOCs") at AK Steel were identified, named, and numbered by USEPA during a 1991-92 visual site inspection ("VSI") and preliminary review ("PR") (PRC 11Dec92).

7 G&M (May 89 pg. 50) does not name the stream which was "rechanneled by Armco to flow to the west of the plant". However, it is said to lie within the ancestral southern flowing tributary valley within South Plant. Reference to G&M (May89 Fig. 20) identifies the creek as North Branch Dick's Creek. Therefore "west" appears to be an error, because North Branch is on the east side of the plant. Assuming that North Branch was diverted to flow outside of the plant boundary, it follows that it was shifted to the east, not to the west. The southeastern jag in the course of the creek at the north boundary of AK Steel also suggests that the creek was redirected to the east. Moreover, the USGS topographic map, Monroe, OH quadrant, indicates a parallel channel within the plant along an alignment absent the jag. This may be the former channel of North Branch Dick's Creek now serving as a portion of the storm drainage system for the plant.

8 Till is an unstratified mixture of clay, silt, sand, gravel, and boulders deposited directly by glacial ice without reworking by meltwater.

9 The G&M (May89) geological cross-sections do not show the depth of borings used to infer the stratigraphy. In many cases the borings extended below the screened well bottom drawn in the figures.

10 Arcadis (16Mar01 Sect. 2.3), referring to historical aerial photographs and other information, infers timing of slag deposition. Between 1961-1966 slag and soil likely were used as fill to raise and level the native farmland to support access and allow construction of the foundations for railroad lines and processing equipment (Arcadis 16Mar01 pg. 4). By August 1966 clearing/filling had begun in the north-central portion of the area (Arcadis 16Mar01 pg. 10). By 1976 slag processing and recycling operations were being performed across the entire northeast portion of the area (Arcadis 16Mar01 pg. 11). By 1993 slag processing and recycling occurred in the western third of the area, and numerous small mounds of material were located there (Arcadis 16Mar01 pg. 12).

11 Boring MDA33S, located on the west side of Monroe Ditch, also has been logged as penetrating slag fill (Arcadis 08Feb02 App. F).

12 An aquitard is a hydrostratigraphic unit, typically corresponding to a fine-grained geological unit such as silt or clay, that impedes but does not completely preclude ground-water flow. (The term aquiclude is used for a layer which prevents all flow).

13 Monroe Ditch reportedly incises into the upper aquifer from the railroad bridge to the area near MDA-01, and from GM-45S to the mouth. However, field data is available to confirm drainage from the upper aquifer to Monroe Ditch only for the shorter interval from the bridge to MDA-33S. (Arcadis 08Feb02 Sect. 4.5.2).

14 More precisely, at the Site it appears that conditions vary from perched (e.g., MD1-01) to "semi-perched" (e.g., MDA25P/GM-35S) (Arcadis 16Mar01 Fig. 17). Meinzer (1923, pg. 41) defines "semi-perched" as a confined aquifer underlying an unconfined aquifer where the latter has higher head. The term semi-perched is rarely used today, and the

## **Contaminants Released to Surface Water and Ground Water at AK Steel**

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corresponding condition generally is not called perched.

15 Arcadis (08Feb02 pg. 56) adds well MDA-33P to this list, but Arcadis (08Feb02 pg. 35) states that the perched unit was not encountered at this location and even renames the well to MDA-33S. (Also see another footnote on this topic).

16 Inconsistently, Arcadis (16Mar01 Figs. 9, 10, 11) show piezometric contours for the perched ground-water aquifer outside of these boundaries. However, those contours are not supported by any of the posted data.

17 The native silt and clay surface contains natural erosional features such as ridges and swales. At one point this topographic relief was said to direct ground-water flow in the perched zone, much as a surface swale controls surface water flow (Arcadis 16Mar01 pp. 28, 29, Sect. 3.4.1); however, Arcadis apparently has abandoned that theory.

18 As of 2001, road dust water is obtained directly from the interception trench treatment system and/or from a source at the main AK Steel plant (Arcadis 08Feb02 pg. 7).

19 Apparently inconsistently, Arcadis (08Feb02 Fig. 7) denotes the west side of the platform as the "liquid dump" area.

20 The recommended pumping pattern uses existing wells plus one reactivated well (G&M May89 pp. 4-5).

21 <The primary reference for this conclusion, G&M (1991) Technical Memorandum on the Updating and Recalibration of the Armco Flow Model Using Data for the Period of November 1989 through October 1990, has not yet been obtained.

22 Another reference indicates that COG is by weight methane (40-50%), nitrogen (10-25%), carbon monoxide (10-20%), hydrogen (10-15%), carbon dioxide (2-10%), ethane (<9%), ethylene (<7%), benzene (<5%), toluene (<2%), hydrogen sulfide (0.1 to 2%) and naphthalene (<1.5%) (Dames & Moore 23Jul98 pg. 1).

23 C. Batliner (20May03 during site visit) described the tar sludge as a mixture of tar and coke breeze.

24 I have no information on coal tar decanter sludge handling prior to early 1983.

25 During the May 20, 2003 site visit Mr. Batliner told others that the K087 waste was sprayed from overhead nozzles onto the coal pile. That dispersal method is inconsistent with the CCA (19May00) description of dumping sludge by bulldozer onto the coal. Clarification is requested.

26 Coke oven gas condensate forms in the primary cooler and typically contains water, tar and naphthalene. At AK Steel the condensate formerly was managed using underground tanks. Typically this condensate is sent to the tar and liquor plant; that may have been the previous practice at AK Steel. In November 1991 the coke oven gas condensate at AK Steel was shown to be a RCRA hazardous waste due to the presence of benzene. By November 1992 the condensate was no longer being stored in underground tanks. Currently it is sent to the City of Middletown sewer system. OEPA has asked Armco to demonstrate that no releases of condensate occurred from the underground storage tanks; I have not seen a response. (OEPA 12Jan93 pg. 2; USEPA Aug97 pg. 5; American Iron and Steel Institute 2003).

## **Contaminants Released to Surface Water and Ground Water at AK Steel**

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27 An unidentified analytical report for a sample received 11/22/91 is attached to OEPA (12Jan93). The sample is named "AGC" ("GC" for "gas condensate"?). The TCLP volatiles analysis detected 3500 ug/l benzene (regulatory limit 500 ug/l) as well as several other compounds. Perhaps this was the COG condensate sample cited in the text.

28 Typically, final cooler wastewater is a contact wastewater which is high in condensed naphthalene and, possibly, in tar introduced to extract the naphthalene.

29 In July 1995 spilled flushing liquor passed through this surface water impoundment. The pond temporarily was used as a source of makeup water on the coal pile spray system to minimize further releases from the facility—this may explain the names of the pond.

30 PRC (11Dec92 pg. 39) indicates that at the time of the VSI the sludge was removed biweekly to gondolas and landfilled. This does not clarify whether the disposal was to onsite or offsite landfills. Currently the sludge is taken to an offsite landfill (C. Batliner during site visit, 5/20/03).

31 No concentration units are indicated on the tables in AK Steel (11Nov99); clarification is requested.

32 There are three temper mills at AK Steel, and judging by their wastewater internal outfall numbers at least one is in each of North Plant and South Plant Areas (USEPA Aug97 pp. 10, 15). I have not been provided with more specific information.

33 PRC (11Dec92 pg. 70) refers to this SWMU as the Hot Slab (or Mill) WWTP. USEPA (Aug97 pg. 9) calls the same facility the Hot Strip Mill WWTP. I have adopted the latter terminology.

34 Waste pickle liquor from the EGL is used at the south terminal treatment plant for pH adjustment (USEPA Sep97 pg. 11).

35 The "EGL" wastewater treatment plant for the Number 2 Electro galvanizing line was under construction at the time of the VSI (PRC 11Dec92 pg. 11).

36 G&M and Arcadis figures indicate an EGL plant within the North Plant Area.

37 PRC (11Dec92 Fig. 9) indicates that the fabricating plant included a galvanizing/conversion coating line.

38 G&M (May 89 pg. 9) mentions that American Materials also was involved in operations at that time.

39 Note that some documents abbreviate this compound as "TCE". However, TCE is also a common abbreviation for another chemical—trichloroethene. In this report, TCE is used only to refer to trichloroethene.

40 The PR and VSI are two components of a RCRA Facility Assessment ("RFA"). "The purpose of an RFA is to summarize available information about a site and to assist USEPA in recommending further steps in the corrective action process. The RFA is the first step in identifying actual or potential releases from the facility. The overall objective of the RFA is to determine whether there is sufficient evidence to require the owner or operator to undertake additional investigations (a RCRA Facility Investigation ["RFI"]) to characterize the nature, extent and rate of migration of the contaminant of concern" (PRC 11Dec92 pg. 1). "The RFA includes a preliminary review (PR) of the data sources to initially identify

## **Contaminants Released to Surface Water and Ground Water at AK Steel**

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SWMUs and AOCs, a visual site inspection (VSI), and an optional sampling visit (SV) to gather additional evidence of releases" (PRC 11Dec92 pg. 2).

41 USEPA's multimedia compliance inspection of AK Steel was conducted to determine compliance with the following regulatory programs: CWA, CAA, RCRA, PCB management under TSCA, UST regulations, and UIC regulations under the SDWA (acronyms are expanded in Section iv). The investigation included review of federal and state files, and on-site inspections including CWA-NPDES sampling, CAA inspection, RCRA hazardous waste inspection, TSCA-PCB inspection, CWA-SPCC plan inspection, and SDWA-UIC inspection. Inspections involved discussions with plant personnel, inspections of facility operations, plant records and documents review, wastewater sampling, and visible emission observations. (USEPA Aug97 pp. 1-2).

42 I am unaware of any such follow-up sampling visits (SVs).

43 The 1992 USEPA Corrective Action Stabilization Questionnaire echoes the PR/VSI in calling for further sampling at SV-designated SWMUs and AOC (USEPA 12Jun92 Sect 18).

44 K087 waste contains the organic compounds phenol and naphthalene (PRC 11Dec92, pg. 47), as well as other organic compounds.

45 For instance at Savannah River Site in South Carolina, coal pile leachate which collected in a seepage basin is acidic. Infiltrating leachate has contaminated the local ground water with principally sulfate, iron, aluminum, manganese, and to a lesser extent chromium, cobalt, nickel, copper, arsenic, zinc, selenium, and uranium ([http://www.uga.edu/srel/Graphics/ecolines1\\_3.pdf](http://www.uga.edu/srel/Graphics/ecolines1_3.pdf)).

46 A large pool of green-colored liquid was observed at this location during my site visit on May 21, 2003. AK Steel attributed the tint to algal growth in puddled cooling water condensate. If that was the case during the VSI as well, then the consistent occurrence of algal blooms in this vicinity also may indicate local releases of nitrogen-rich water such as flushing liquor.

47 Well DMW-6d is believed to tap a thin sand and gravel unit which is hydraulically connected to the Upper Saturated unit (Dames & Moore 19Jun97 pg. 5).

48 Dames & Moore (23Jul98 pg. 11) states that before-and-after water quality samples are tabulated in its Table 2, but that is incorrect.

49 GM-04S also is unique at the Site in exhibiting detectable dissolved arsenic, according to April 1991 data (OEPA 01Dec99 Att. 4c).

50 It is not clear from provided documents that the source actually has been identified. "At a minimum, the site characterization phase should provide data on the location and extent of contaminant sources?" (G&M Sep97 App. A pg. 318). I am unaware of any benzene-contaminated soil samples from the tank area.

51 G&M (06Nov92 pg. 13) actually states that the aquifer is "confined" by till at GM-52S, but misuses the term. Although at GM-52S till overlies the upper aquifer, the water table lies below the base of that till and the aquifer is therefore unconfined (G&M 06Nov92 Fig. 8, Table 3).

52 The southwest to west direction of ground-water flow implied by the piezometric surface in the benzene investigation area does not agree with the inferred due-south

## Contaminants Released to Surface Water and Ground Water at AK Steel

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direction of benzene migration. This inconsistency was recognized by G&M. G&M refers to lithological changes along the western boundary of the benzene investigation study area as possibly diverting flow toward the south. (G&M Sep97 Sects. 2.1, 3.1, 3.3.3). However, such an effect also would manifest in a curvature of the piezometric surface, and none is evident.

53 The OEPA Investigation Report states that the May 10, 1991 spill occurred in the drainage area of NPDES outfall 002. The OEPA Investigation Report for July 9, 1991 states that the spill entered a holding pond which is tributary to outfall 002. A June 29, 1992 Investigation Report concerning a tributyl tin release quotes C. Batliner as stating that the June 26<sup>th</sup> flushing liquor spill would have drained to outfall 002. In contrast, the major July 26, 1995 spill entered Dick's Creek at outfall 003.

54 Some of the reported environmental samples may not have been collected in a manner which prevented loss of volatile constituents. For instance, a 7/26/95 sample at outfall 003 apparently was a 24-hour composite sample. Unless special precautions were taken, it is likely that the compositing procedure allowed volatile compounds to escape and therefore that the results understated or even failed to detect VOCs in the effluent.

55 A November 4, 1992 OEPA inspection noted that the area continued to be used for coal storage (OEPA 04Nov92).

56 The statistically-based procedure used to establish background limits neglects to assess whether soil quality in the K087 area as a whole differs significantly from background. The background limits are only applied one sample and one chemical at a time. This is not a conservative (precautionary) approach. The non-conservative nature of the approach is amplified by setting limits based on two-standard deviations (a high criterion) and using log concentrations (a log plot acts to increase the limit compared to an arithmetic plot).

57 benzo(a)anthracene, benzo(a)pyrene, benzo(b)pyrene, benzo(k)pyrene, and indeno(1,2,3-cd)pyrene

58 Additional chemicals may exceed the VAP standards when, per the regulation, cumulative adjustments are made for the presence of multiple regulated chemicals in the samples.

59 Coal tar constituents at AK Steel are tabulated in CCA (19May00 Table 1).

60 A site near the Mississippi River serves as an example of the difficulty of anticipating subsurface behavior of light nonaqueous phase liquids ("LNAPL") such as diesel fuel in real-world, heterogeneous conditions. At that site LNAPL was spilled, and this was followed by a period of intense precipitation and infiltration. The LNAPL apparently was driven 10 or more feet downward (either as continuous oil or entrained droplets) through saturated fractures of a silt-clay stratum and into an underlying sandy stratum. Once in the sand, the LNAPL moved laterally, rose due to buoyancy and coalesced as entrapped LNAPL in the upper portion of the sand, much like a natural crude oil deposit. This unexpected sub-water table LNAPL reservoir then leached LNAPL constituents into passing ground water. (Sylvester 1985). Such **stratigraphic trapping** of LNAPL below the water table, although usually unexpected, is not unique and can be induced by man-made or natural processes (Vroblesky et al. 1995).

61 A November 4, 1992 OEPA inspection notes that SPL was no longer being sent to the Ashland facility (OEPA 04Nov92).

## **Contaminants Released to Surface Water and Ground Water at AK Steel**

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62 "K-well" as denoted in G&M (May89 Fig. 3) apparently is the well logged as "K-78" in G&M (May89 App. A) and denoted simply as "K" in Arcadis (06Feb98) and other documents.

63 Arcadis (06Feb98 pg. 7) states that its conclusions are based on "historical information" but the main text does not describe the review of historical information.

64 TCE is used, released, disposed of, and recycled in significant amounts (tens to hundreds of thousands of pounds per year) at iron and steel facilities (USEPA Sep95 Exh. 7, 8).

65 The Ohio Water Quality Standard for pH is the range 6.5 to 9.0.

66 Colloids typically are defined as particles 0.01 to 10 microns in diameter.

67 In the Slag Processing Area high pH has been detected nearly everywhere within the perched zone—except west of Monroe Ditch where no slag is deposited—and in many wells within the upper aquifer. The highest pH perched water was recorded in the finished slag area at MDA22PR (pH = 12.64). The high pH upper aquifer waters are located primarily in the raw slag area in north-central OMS Area (maximum pH = 12.3 at MDA27S), but other high pH locations also exist. The pH distribution at the Site has proven useful in interpreting ground-water flow conditions, but is not a reliable surrogate for PCBs occurrence. (OAG 29Jan98 pg. 7; AK Steel 11Nov99; Arcadis 16Mar01 Sect. 2.8.2, Table 7; Arcadis 08Feb02 pp. 75, 77, 89, Figs. 42, 43).

68 A similar finding was made with respect to ground water entering the Monroe interception ditch. Filtration through a 0.45 micron filter reduced total PCBs from 4.56 to 1.72 ug/l; filtration through a 0.001 micron filter (1 nanometer) reduced total PCBs of 3.24, 4.42, and 4.51 ug/l to nondetectable in each case, with a detection limit of about 0.2 ug/l. (Arcadis 20Jul99).

69 Arcadis (15Jul99 pg. 13) clearly explains that soil sample SS05 was located at the pole-mounted conveyor transformer and that SS06 was located at a utility pole not associated with any transformer. (The location of SS06 shifts by several hundred feet between Arcadis documents—see a separate footnote). Nevertheless later Arcadis documents confuse these results with each other and with those obtained at the concrete pad-mounted conveyor transformer station. See, for instance, Arcadis (16Mar01 pg. 16) and Arcadis (08Feb02 pg. 19).

70 Inconsistently, Arcadis (08Feb02 Fig. 32, Table K-1) posts 0.38 mg/kg PCBs for the 0-2 ft bgs sample (which is labeled MDA-BH22 (0-2)ave in Table K-1).

71 Inconsistently, Arcadis (08Feb02 pp. 23, 90, Table K-5) states that at MDA22P 6.33 ug/l PCBs were detected in a July 1, 1998 sample (MDA-22P) and 4.1 ug/l in a July 13, 1998 sample (PW-MDA-22P). I have not found any earlier record of these results.

72 Sample BH26SL consisted of soil within the perched zone immediately above the hard grayish black clay that was logged from 12-14 ft bgs (Arcadis 08Feb02 App. B, boring log for BH26SL).

73 Inconsistently, Arcadis (08Feb02 Fig. 34) places boring BH26SL north of Mill Scale Area 1 and reports a November 1998 soil sample result of 0.2854 mg/kg for the interval from 12-24 ft bgs. According to the boring log no such sample was collected.

## **Contaminants Released to Surface Water and Ground Water at AK Steel**

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74 Arcadis (08Feb02 pg. 21, Table K-5) states that a July 1998 sample (PW-MDA-03P) from MDA03P contained 3.60 ug/l PCBs. I could not find any earlier mention of this sampling result.

75 One can imagine a PCBs pathway from Mill Scale Area 3 to the upper aquifer at MDA08S, involving contaminant migration through the native clay close to MDA08P or errors in the upper aquifer piezometric contours due to widely spaced wells.

76 Inconsistently, Arcadis (15Jul99 pg. 19) states that PCBs were detected in native clays in BH08 at a depth of 15-17 ft, but Arcadis (15Jul99 Table 8) states that the sample was ND for PCBs.

77 Inconsistently, Arcadis (08Feb02 pg. 22) states that in 1998 boring BH13 at 6-8 ft bgs contained PCBs at 12.7 mg/kg; however, no such result is shown in Arcadis (15Jul99 Table 8) or Arcadis (08Feb02 Tables 14, K-1). It is possible that the value was mistakenly drawn from an August 2000 boring BH13-S50 which did have 12.7 mg/kg at 6-8 ft bgs.

78 Inconsistently, Arcadis (15Jul99 pg. 19) states that the 1998 MDA08P concentration is 19.5J ug/l, whereas Arcadis (15Jul99 Table 9) shows a result of 13.1 ug/l.

79 PRC (11Dec92 pg. 121) and Frost & Jacobs (03Dec99 Appendix K) state that the landfill operated from 1965 to 1980.

80 Arcadis (08Feb02) is inconsistent and incomplete in its documentation of soil boring samples from this location. According to Arcadis (08Feb02 pg. 35, App. F) two borings were drilled: MDA35S and, five feet to the south, MDA35SR. The boring logs indicate that the first boring was sampled only at depths 0-2 ft and 6-8 ft bgs, and that no samples were taken from second boring. However, according to Arcadis (08Feb02 Table K-1) four depths were sampled, including 0-2, 6-8, 10-12, and 16-18 ft bgs, and all of them were from MDA35SR. (Boring MDA35S was abandoned due to landfill gas [Arcadis 08Feb02 Sect. 3.1.1, pg. 35]).

81 Inconsistently, Arcadis (08Feb02 pg. 35) states that MDA-33S is open to native sands, but the boring log and construction diagram place the well screen in saturated slag. Saturated slag generally is interpreted to be the perched unit, but Arcadis (08Feb02 pg. 35) stresses that the perched unit was not encountered. To add to the confusion, the water sampling log for MDA33S records a sounded depth of 22.36 ft and sample pump intake of 21 ft (Arcadis 08Feb02 App. H) which are impossible because the well is only about 11 ft deep (Arcadis 08Feb02 App. G). (On the other hand, the sounded depth of 22.36 ft and the depth to water of 10.81 ft exactly match those of well MDA32S, suggesting a transcription error).

82 PRC (11Dec92 pg. 124) also states (inconsistently?) that the fill was capped in 1980-1981.

83 Inconsistently, Arcadis (08Feb02 pp. 29-30) places BH15-02 and BH15-03 within the large ponds, but Arcadis (08Feb02 Fig. 4) posts them well outside of the ponds. Boring MDA32S is consistently placed within the westernmost large pond.

84 Inconsistently, Arcadis (08Feb02 Figs. 32, 33, Table K-1) shows detections of PCBs at two depths of boring BH09 in June 1998, whereas Arcadis (15Jul99 pg. 16, Figs. 3, 5, Table 8) shows non-detectable PCBs for both samples.

85 The seeps area of Monroe Ditch is adjacent to the interception trench, approximately in the middle of the OMS Area (e.g., Arcadis 08Feb02 Fig. 4).

## Contaminants Released to Surface Water and Ground Water at AK Steel

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86 I have been unable to ascertain the source of Arcadis' topographic contours of the native clay surface for the first report. The second report apparently has contoured observed top-of-clay elevations from site borings (Arcadis 08Feb02 pp. 31, 57).

87 Arcadis (08Feb02 pg. 93, Fig. 46) speculates that two recently observed ground-water seeps in Monroe Ditch (seeps #5, #6) in the SW corner of the OMS Area near well nest MDA09S/P, substantially south of the "seeps area", "are thought to be associated with flow in the Former Drainage Path". These seeps did not contain detectable PCBs.

88 Apparently the AK Steel property line lies some 800 ft south of the tracks. I am unaware of any environmental data concerning that portion of the property. In particular, there is no information on whether slag has been deposited there, whether the perched aquifer exists there, or whether PCBs have migrated there.

89 I have been unable to find out why these two upper aquifer wells are installed within 10 feet of each other (Arcadis 08Feb02 Table 2).

90 In a deliberately biased sediment sampling program selecting for high fines content, 17 of 23 sediment samples contained greater than 40% silt and clay (Arcadis 15Jul99 pp. 23-24, Table 14).

91 Oddly, a page after the cited quote concerning high proportion of sand-size and greater material in the streambeds, Arcadis (15Jul99 pg. 25) states that there are "high percentages of silt and clay typically found within Monroe Ditch and Dick's Creek". The latter claim is made to argue that "stream sediments are not likely to be heavily scoured and deposited" (15Jul99 pg. 25). Perhaps the high silt and clay percentages relied upon were those from the deliberately biased samples (see previous footnote). What is clear at this point is that the magnitude of channel scour and downstream transport has not been determined, and that the process carries detectable PCBs miles downstream from AK Steel.

92 I tentatively place this sample about 250 ft downstream of the confluence with Monroe Ditch.

93 Detections of PCBs in 1995, prior to implementation of the slag and kish drenching operation, argue against it playing a pivotal role in mobilization of PCBs from the Slag Processing Area.

94 Arcadis (08Feb02 Sect. 2.6.3 pp. 22-23) inconsistently states that only two significant source areas exist, yet lists three of them. The third one, Finished Slag Area, refers to an area which includes the conveyor belt-transformer and MDA-22. No explanation is provided. Perhaps Arcadis envisions a more widespread source that may be responsible for the PCBs at seeps #10 and #22.

95 Arcadis (08Feb01 App. K) contains a table of these standards, but it is out of date. The current tables are available at <http://www.epa.state.oh.us/derr/vap/rules/vaprules.html>. In addition, many of the standards are for a single chemical and may require downward adjustments when more than one listed chemical is present; procedures are described in the cited document.

96 Unlike for most wells, no cadmium, iron, or nickel results for MDA-23P are reported in Arcadis (08Feb02 Table K-8).

## **Contaminants Released to Surface Water and Ground Water at AK Steel**

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97 For instance, a June 1989 spill of concentrated sulfuric acid "soaked into the ground". The response was limited to application of soda ash and lime (OEPA PIR #6-9-2315).

98 Six internal NPDES monitoring points also exist. They are at treated waters from 613/Blast furnace & Sinter plant, 631/BOF, 005/Hot Strip Mill, 641/South Terminal WWTP, 642/EGL WWTP, and 614/North Terminal WWTP. ("WWTP" abbreviates wastewater treatment plant).

99 River miles increase in the upstream direction, with 0.0 mi. assigned to the mouth of a river.

100 In OEPA (20Dec97) sediment metals concentrations are ranked according to the classification schemes of Kelly and Hite (1984), Persaud (1994), and OEPA (OEPA 30Dec97 pp. 16, 182).

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DATE 8/7/2018  
RIN #  
INITIALS

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12/19/03

**Mikulka Comments on the Draft Motion in Opposition to AK MSJ**

These are the comments of Mike Mikulka, USEPA Region 5, WPTD, on the draft subject Motion. Due to time constraints, I have not discussed these with USEPA Region 5 Counsel, my management or technical staff in the Water Division.

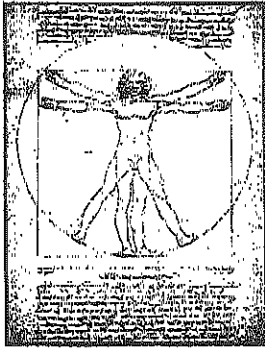
1. Under IV. **Argument, B**: We need to see Chirlin's affidavit. Could be a major blunder about to happen. This is a case where a discharge of pollutants to a surface water body occurs beneath the surface of a water body. That has been shown by the results of the Soil and GW Investigation Report. It happens there are also seeps. If you want to reword this section, I would say it as follows: "Claim 5 does not allege that AK is discharging pollutants to a surface water body ..." (That is in claim 8, the RCRA claim).
2. Under IV. **Argument, B**, last line: drop the word "above".
3. Under IV. **Argument, C**, in the title, you should consider dropping "Unpermitted".
4. Under IV. **Argument, C4**, the second paragraph needs a rewrite of the sentence that begins "This is ridiculous ...". Try: This is ridiculous since the correct solution would be, in the first instance, to locate and remove the PCBs or PCB materials which were disposed on the AK Steel property and are being discharged, or, in the second instance (if that were not possible), to intercept the seeps containing the PCBs before they enter surface waters and convey them to a waste water treatment facility that would treat the pollutants prior to preferably recycling the water, or as a last resort, discharging the treated water under an NPDES permit.
5. Under IV. **Argument, C4**, the 4<sup>th</sup> paragraph needs a few changes. Third line insert "an NPDES" before "permit". The next sentence, change "would" to "could". The sentence after that, change "employed" to "used". I am not sure where you are going at the end here and would need to see Chirlin's affidavit.
6. Under IV. **Argument, D**, the paragraph that begins "Here, the factual evidence..." has one error: there are no known "containers" that are discharging PCBs. Take that out. The later discussion (in the next paragraph) in the brief of landfills as containers is **totally wrong and needs to be removed**. Containers and landfills are defined at 40 CFR 260.10. You may also want to add at the end of this paragraph that some of the seeps identified are coming out of ditches or channels, as such clearly fall within the definition of point sources. This is a lot stronger than what you have there.
7. Under IV. **Argument, D**, the paragraph that begins with "Defendant cites *Friends of ...*": In the sentence right after *Id.* 1359, rewrite as follows: *Here, by contrast, AK Steel has managed wastes and by-products and residues in the area south of Dick's Creek currently known as the OMS area, and has buried pollutants both in un-lined landfills*

and beneath piles of slag, kish and mill scale which it is processing via contract with OMS. This "processing" continues today (see Exhibit \_\_\_ to AK's Brief in Support of its MSJ) at the behest and for the benefit of AK. Later in this paragraph, there are some ambiguous references which relate to Dr. Chirlin's affidavit. It is not that clear what you are doing but the "channeling" concept appears bogus. A channel is a conveyance for surface water, see Webster's dictionary. Dr. Chirlin's concept is a new definition of a channel and I recommend you take it out. We don't need it to make the point and it hurts us to use strained interpretations.

8. Under **IV. Argument, D**, the paragraph that begins with "Defendant cites *Friends of ...*" the last sentence is unclear and not really to the point. Try: *Moreover, the United States (and AK!) believes that process operations at the OMS area were a contributing factor to at least some of the PCB discharges.* See Chirlin affidavit and AK water use document and Soil and Ground water Investigation Plan. (Turn Barber's affidavit back on him.)
9. Under **IV. Argument, D**, the paragraph that begins with "Moreover, while the *Friends of ...*": Beginning with the second sentence, rewrite as follows: *As the Court explained, this "overburden" pile was a byproduct of the defendant's mining operations and the source of the pollutants which were being discharged. Id. at 1337. Here, similarly, Plaintiff believes that pollutants are being discharged from numerous pollutant disposal areas at the Facility which have been covered by byproduct from Defendant's steel-making operations which cause water accumulating or being sprayed on the surface of the Facility to be channeled beneath the byproducts and collected and discharged to surface water having picked up the pollutants from where they were initially disposed.* See Chirlin affidavit.
10. Under **IV. Argument, D**, the paragraph just after footnote 11 that begins with "Here, there is no dam involved", add: *The PCBs were introduced to landfills or other solid waste processing areas by AK or its predecessors, and are being flushed out of those disposal areas through AK's continuous processing of byproducts on or over the past disposal areas.*
11. Under **IV. Argument, D**, the paragraph that begins with "AK Steel also asserts that", change the last sentence to read: *Here, by contrast, AK's landfills and other PCB disposal areas which are now sources of PCBs, are not navigable bodies of water.*
12. Under **IV. Argument, D**, the paragraph that contains footnote 12, change the sentence which begins with "Finally" and the one after it to read: *Finally, it is absurd for AK Steel to assert that it has taken no action to cause the PCB-contaminated seeps, when it was AK Steel that created the un-lined landfill and other disposal areas at the Facility, at least one of which is the source of PCBs, which are discharging to surface waters through seeps. If this landfill and the other disposal areas had not been created by AK Steel, and the area subsequently covered with up to 22 feet of byproduct by AK and its*

*contractors, those ...*” It is dangerous to focus on only one landfill when it is clear that more than 1 source exists.

13. **Under IV. Argument, E**, the 4<sup>th</sup> paragraph, add “and is not within the OMS operated area of AK’s property.” prior to the sentence that begins “For example ...”.
14. **Under IV. Argument, E** the sentence that begins with “Moreover, AK Steel exercises significant control ...” You should emphasize the portions of the contract where AK directed the “Contractor (OMS (page 43 of 72 of the fax) ) shall operate and maintain the kish pot watering equipment in a manner that does not interrupt operations of the Owner’s steel shop.” even though it knew at that time (based on its consultants First Interim report) or should have known that the kish pot watering was flushing out PCBs to Monroe Ditch.



# *Scientia Veritas, L.L.P.*

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## FACSIMILE TRANSMITTAL SHEET

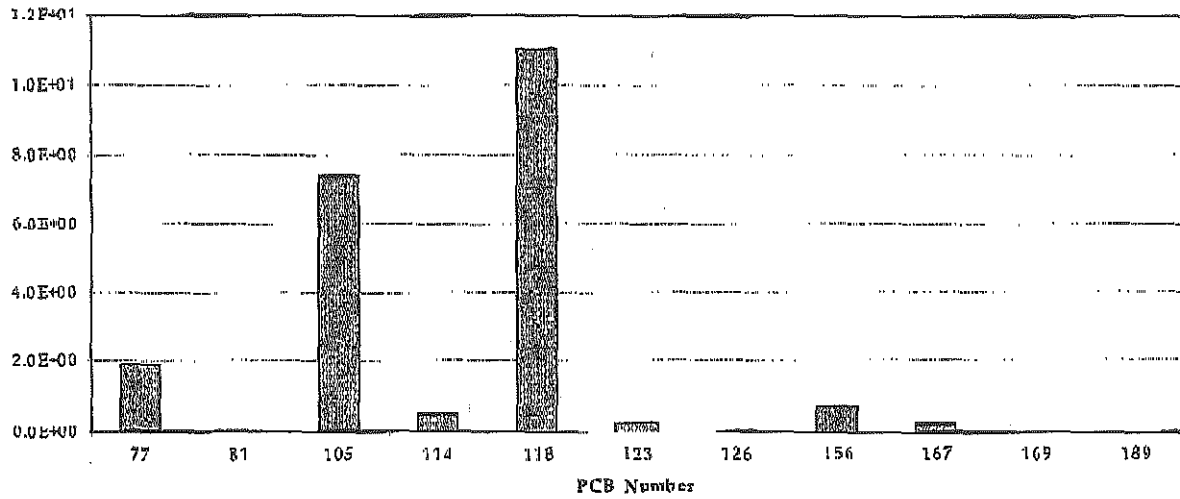
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Company:	Telephone Number: <i>(303) 674-8751</i>
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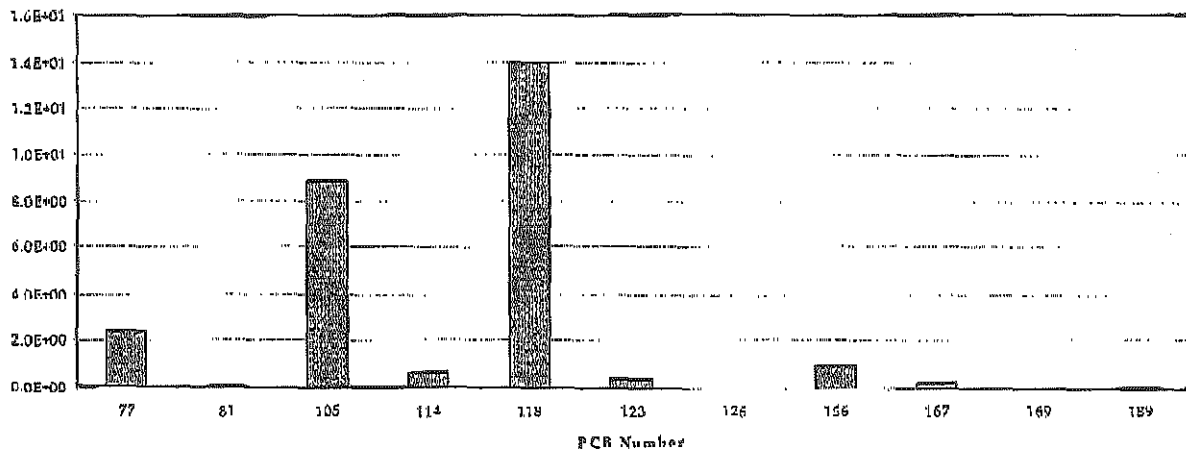
Attached is the second set of histograms for the sediment samples showing the dioxin-like congeners. Mike, I have decided that the background samples should be limited to S18, S19, S20, S21. So we will have to modify the map to show an increased area in AOC1 and a decreased area in background.

Regards,  
Richard

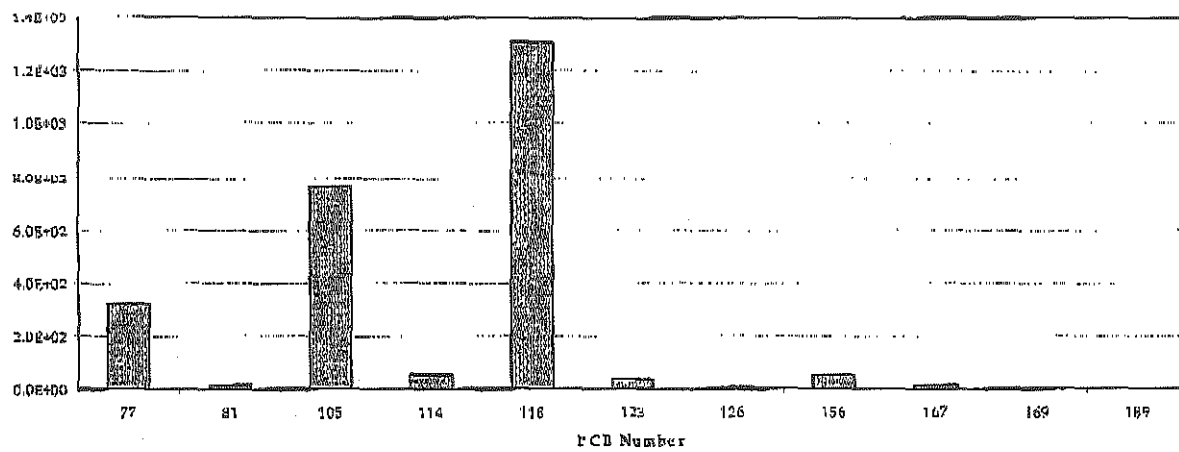
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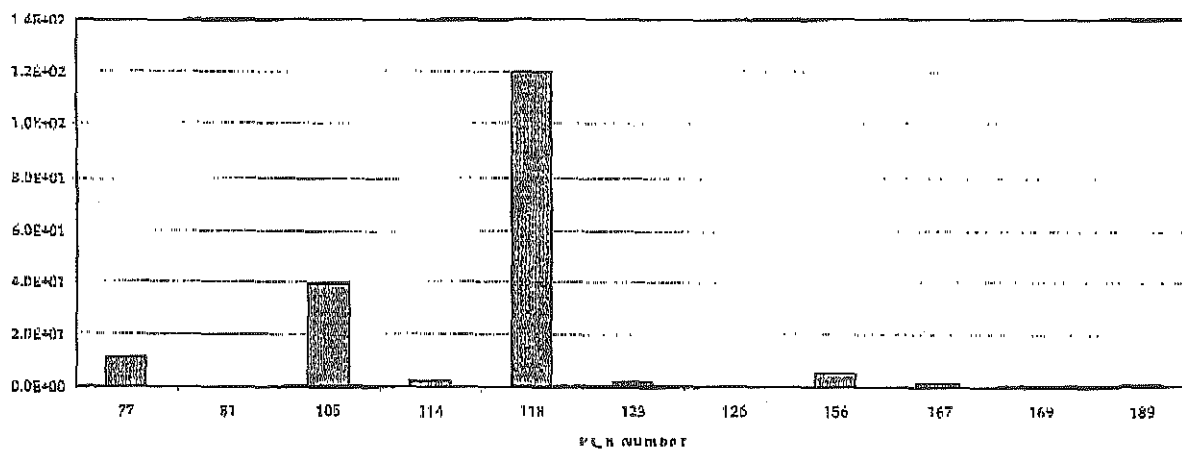
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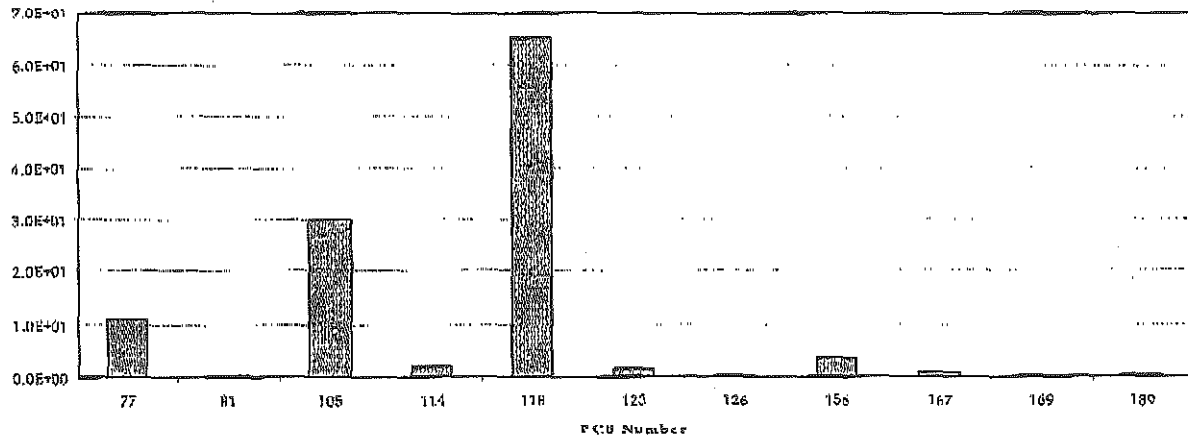
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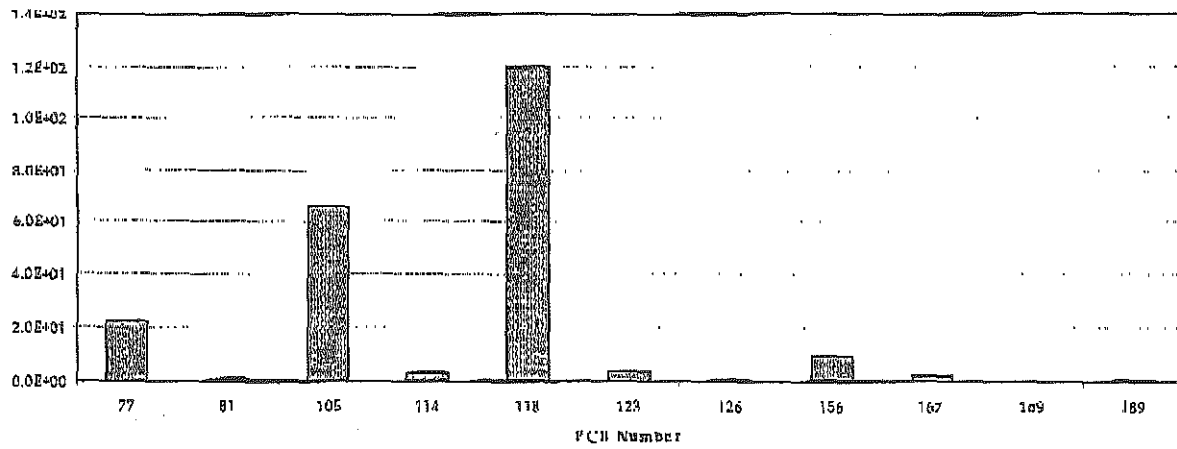
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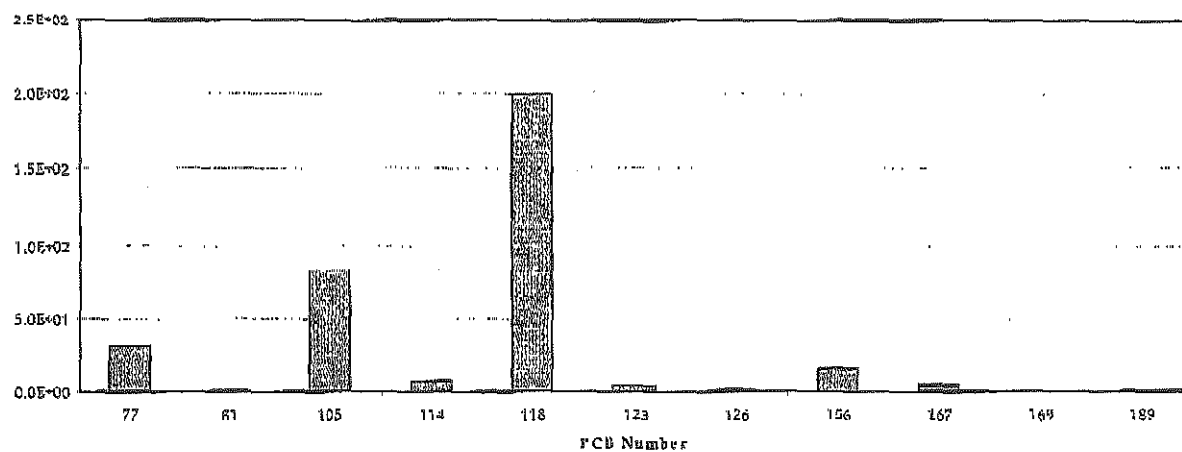
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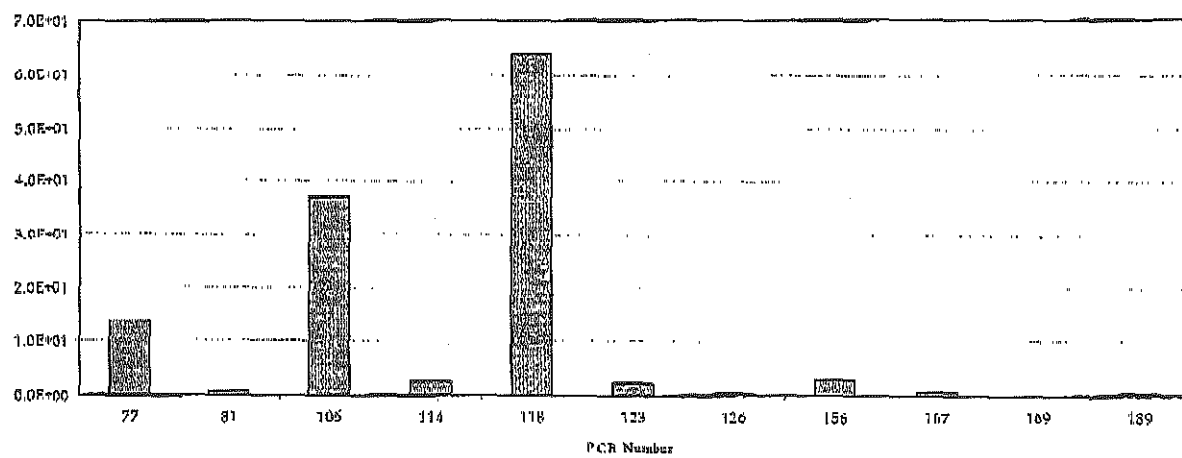
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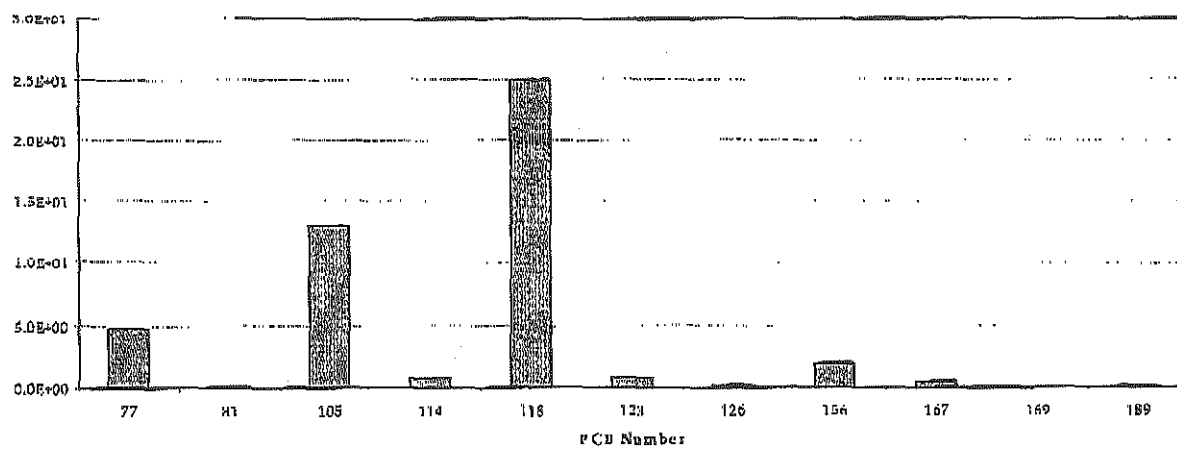
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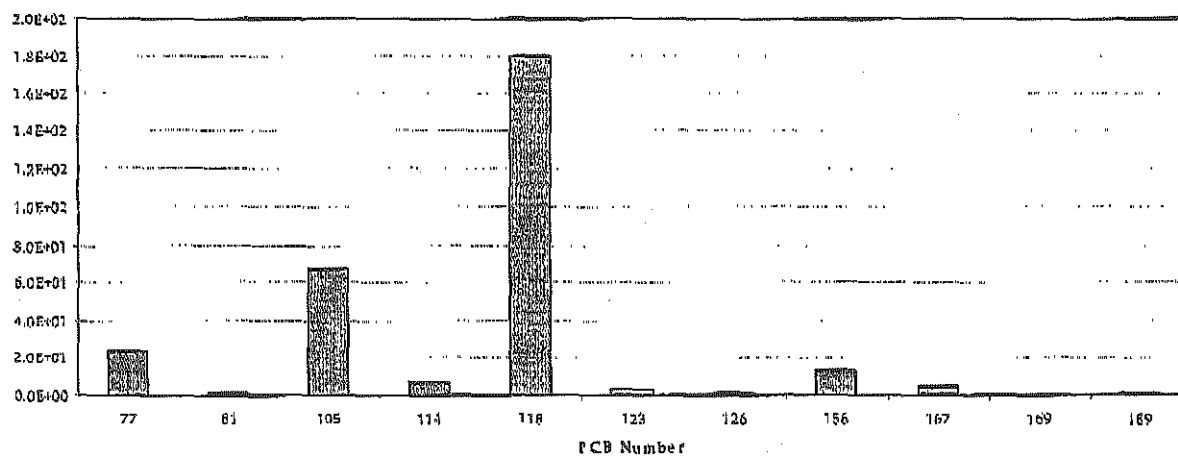
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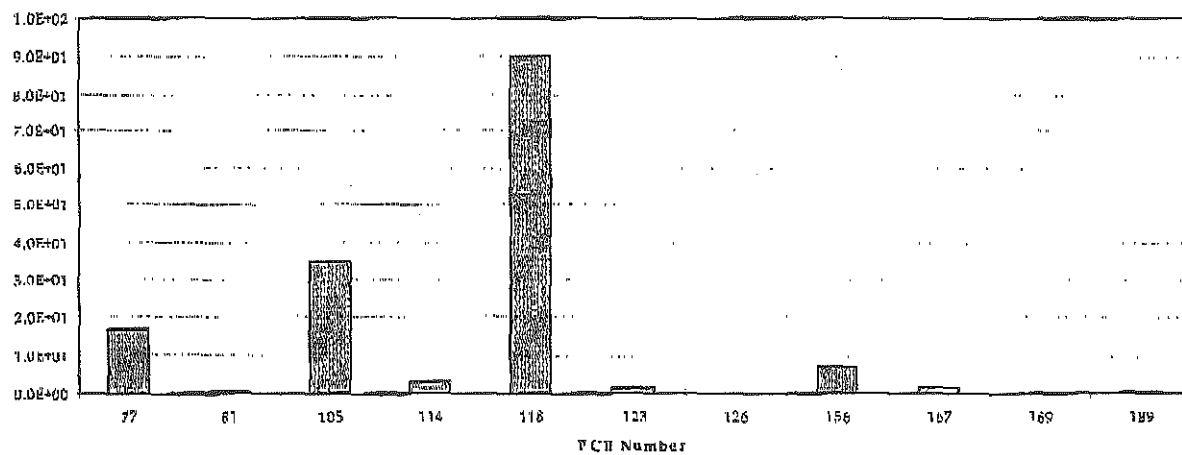
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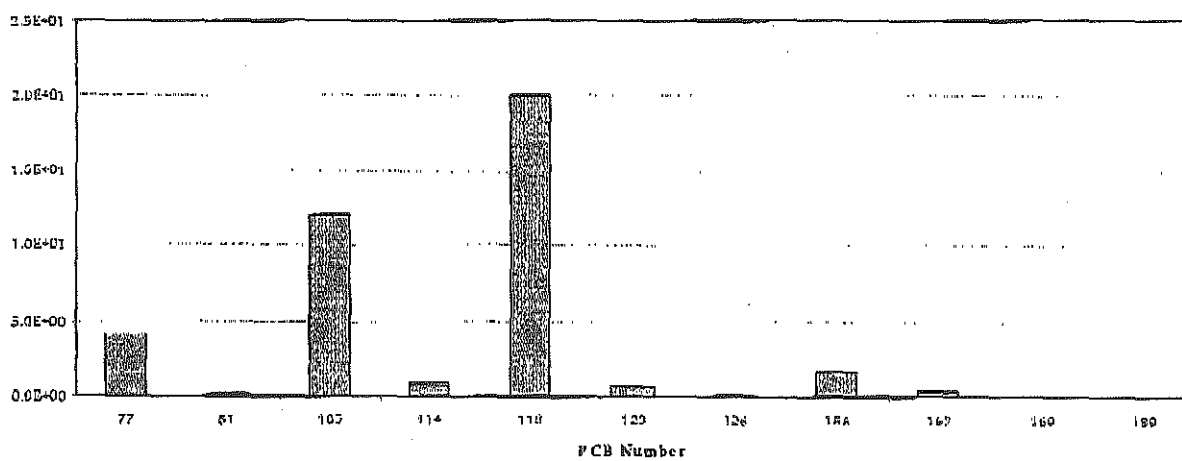
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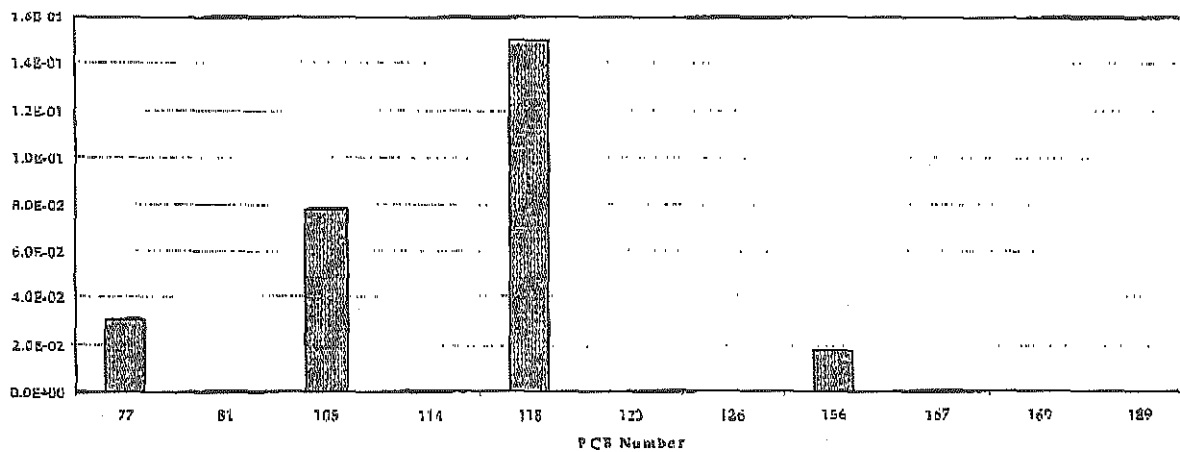
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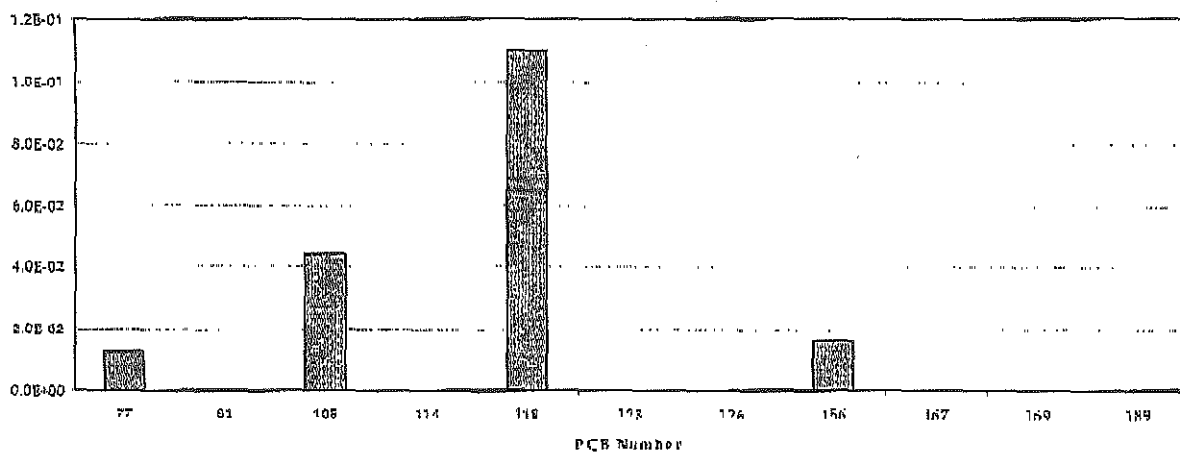
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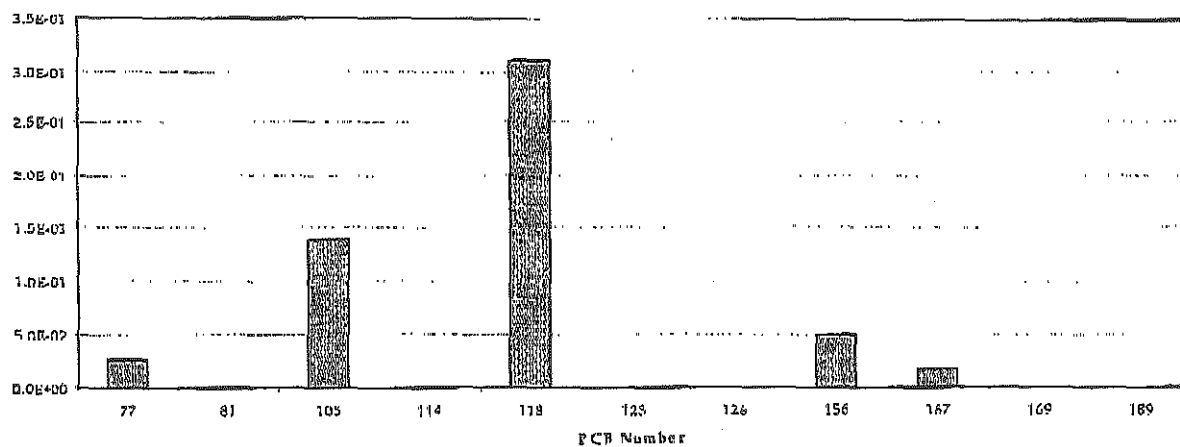
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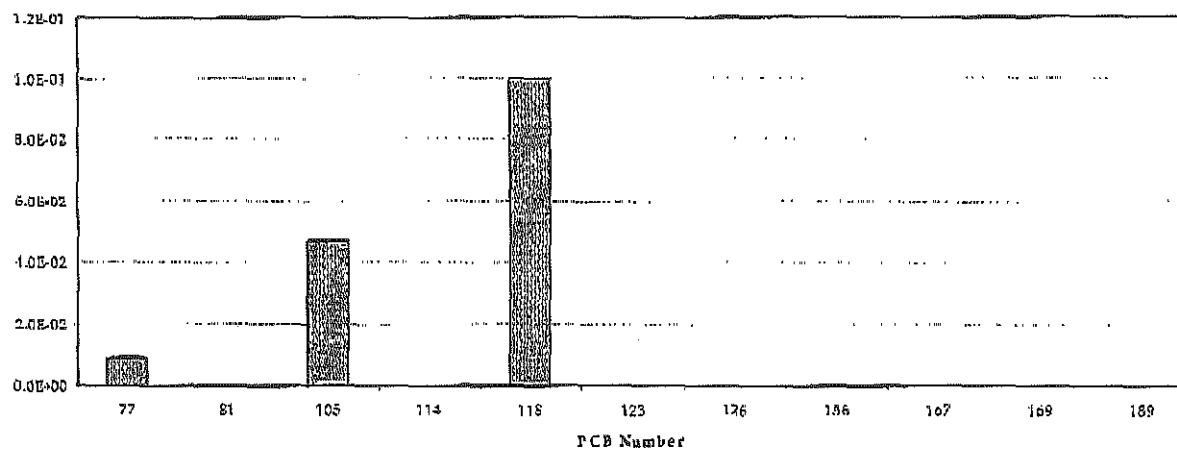
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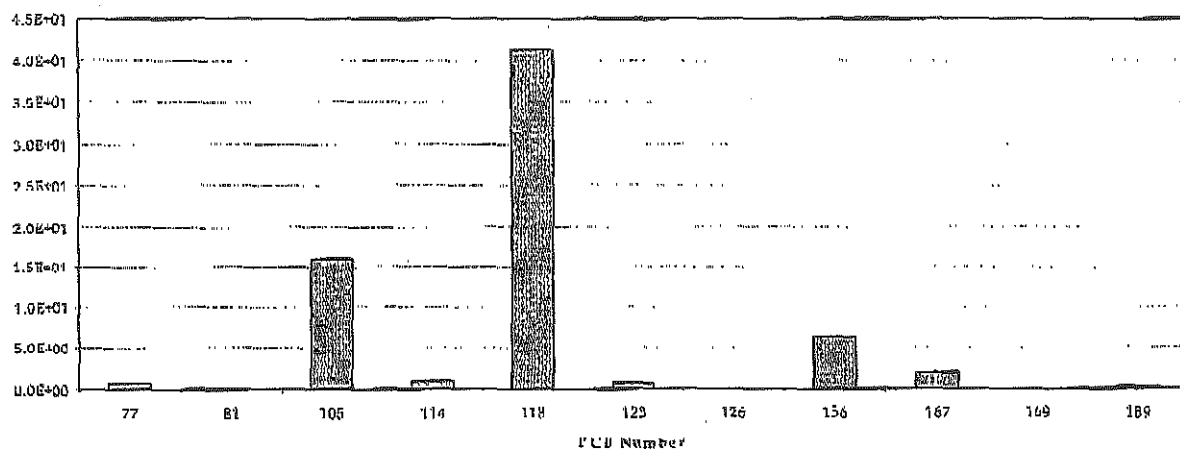
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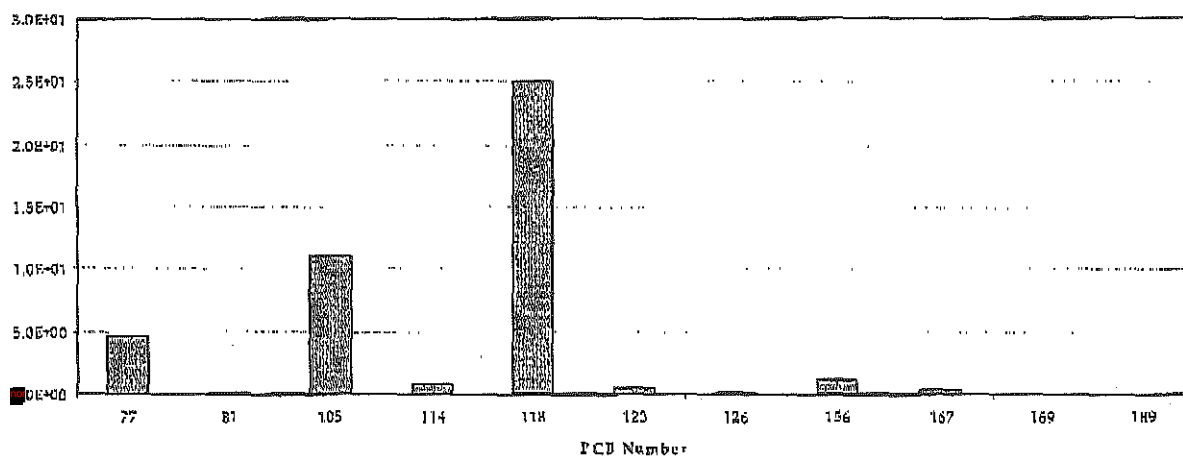
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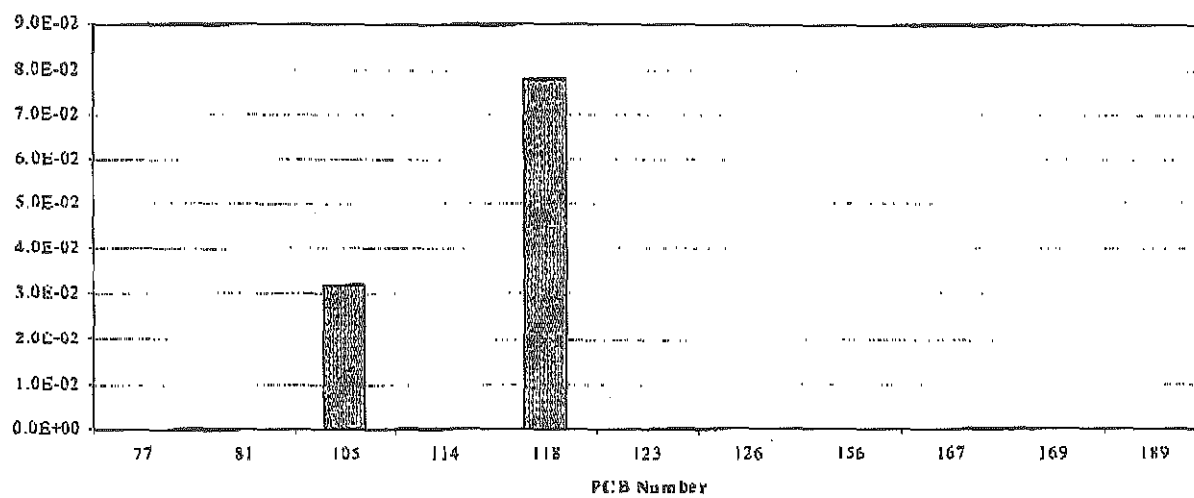
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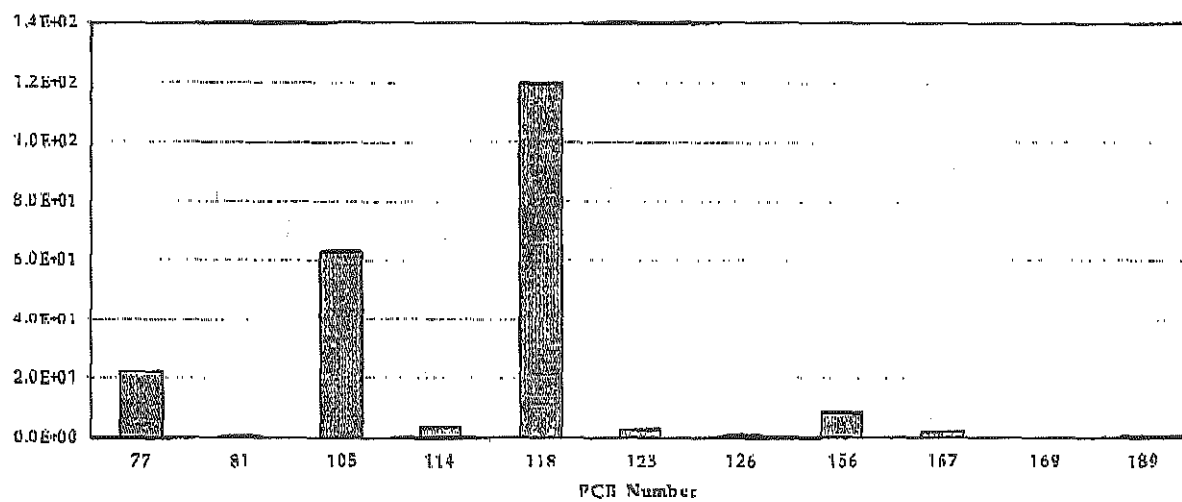
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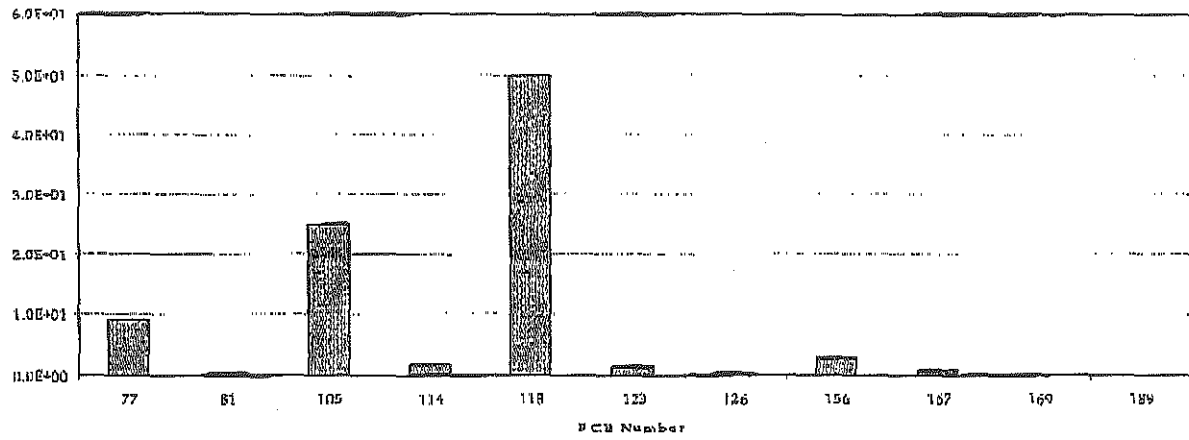
Sample R38



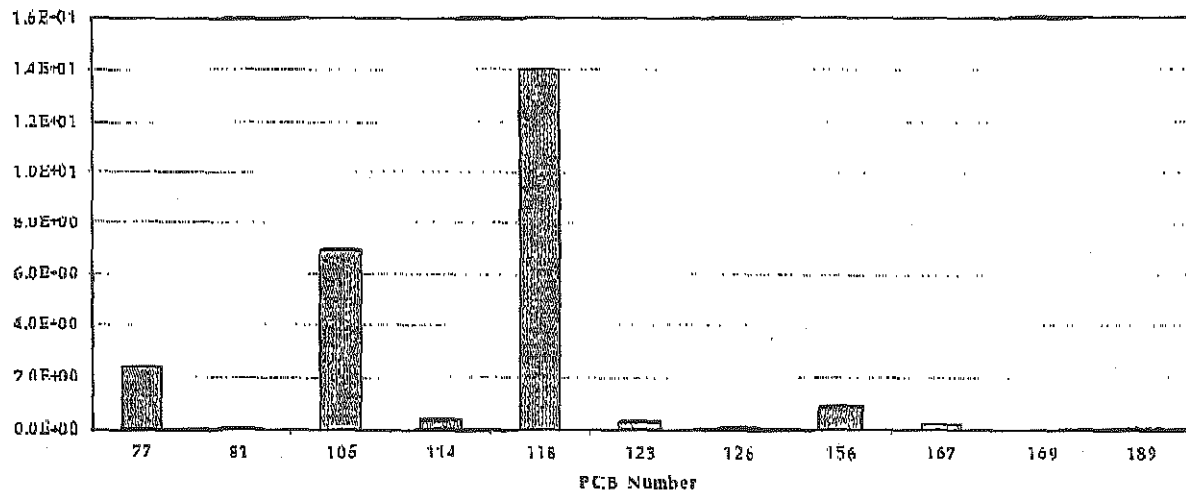
Sample S01



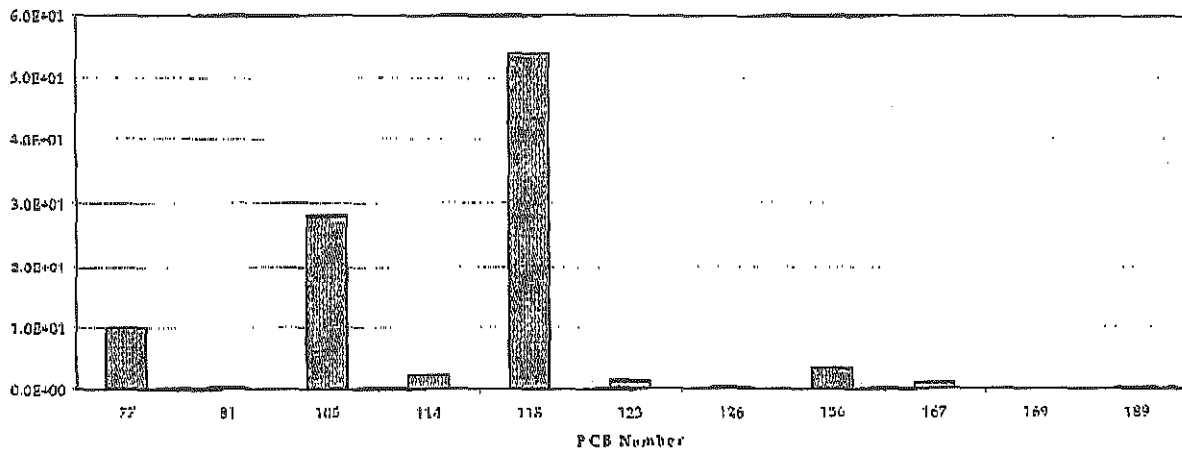
Sample S03



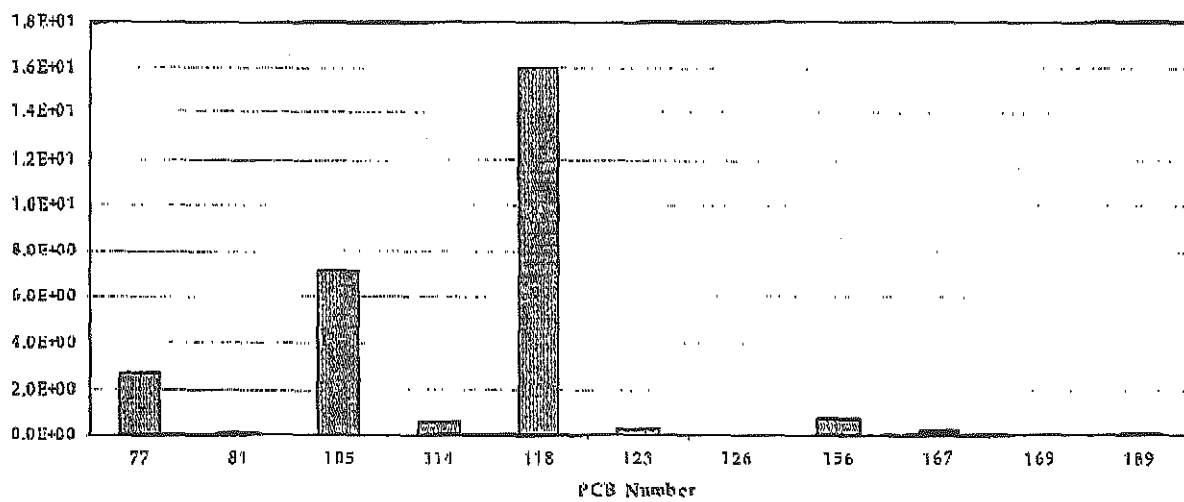
Sample S04



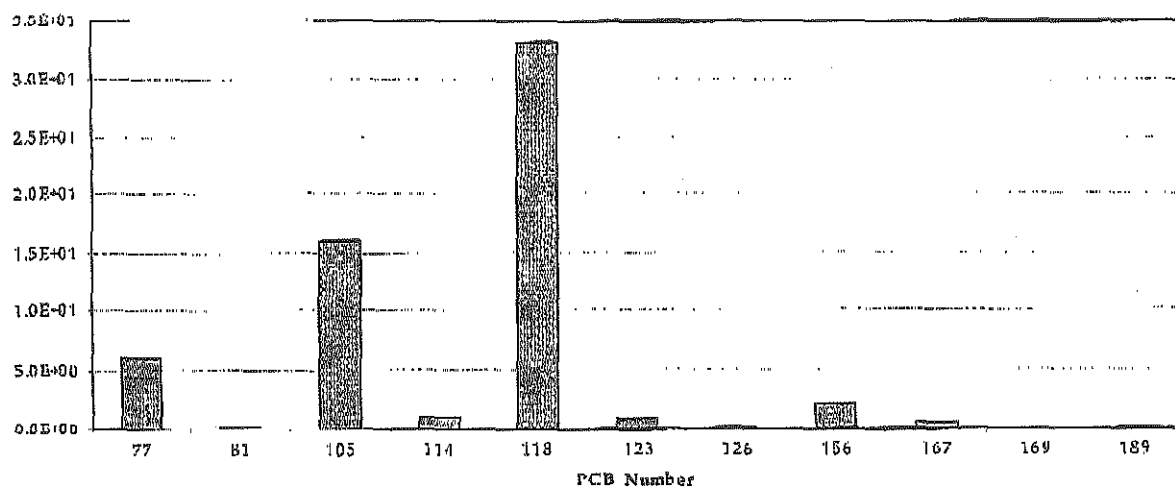
Sample S05



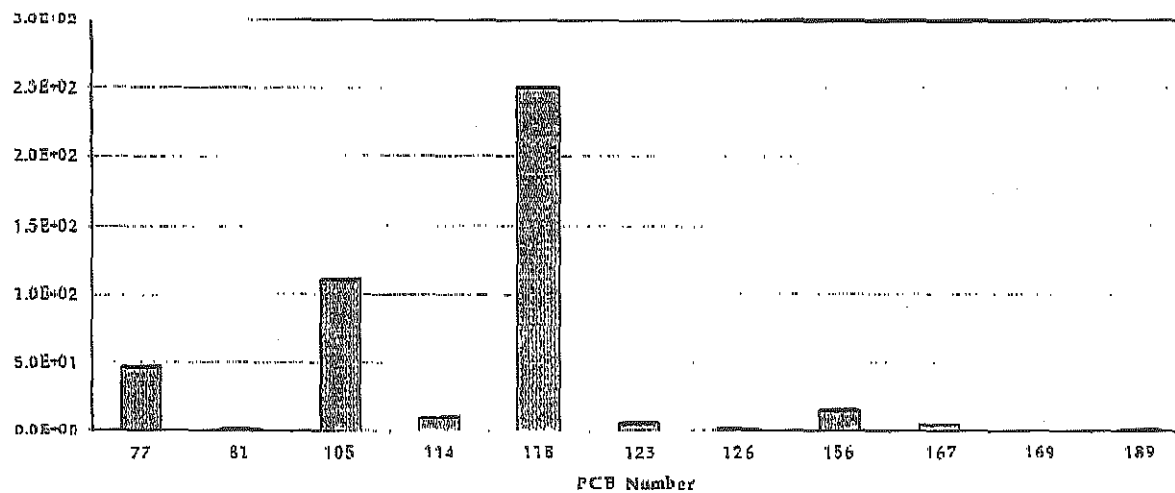
Sample S06



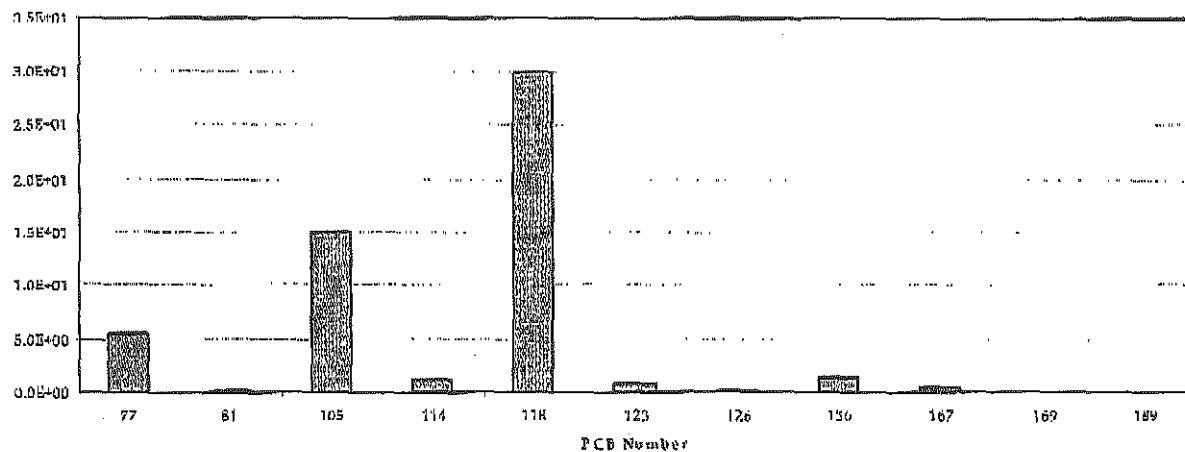
Sample S10



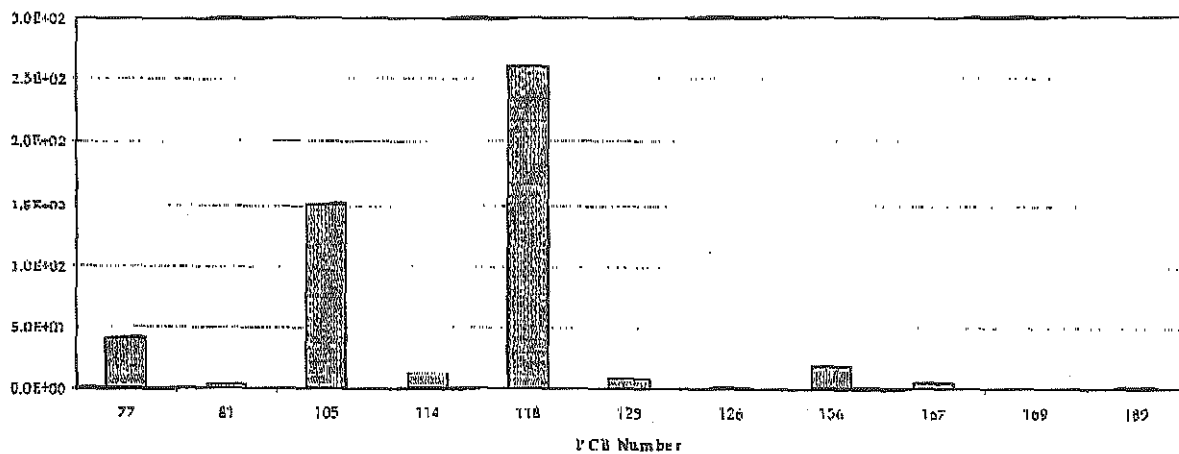
Sample S12



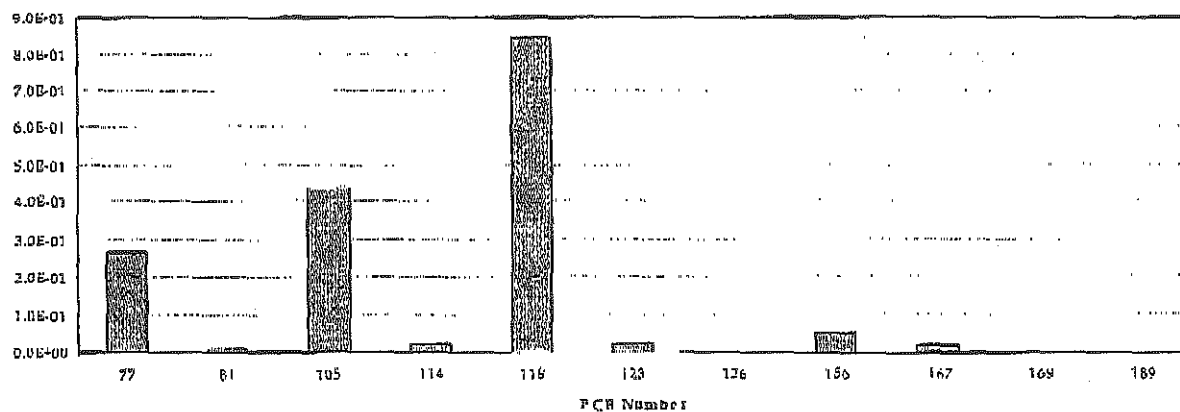
Sample S13



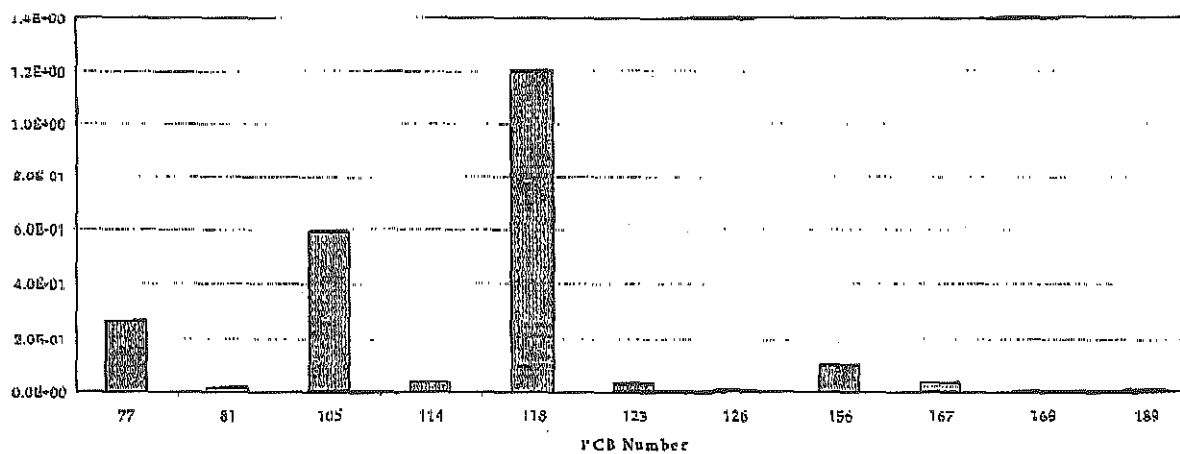
Sample S14



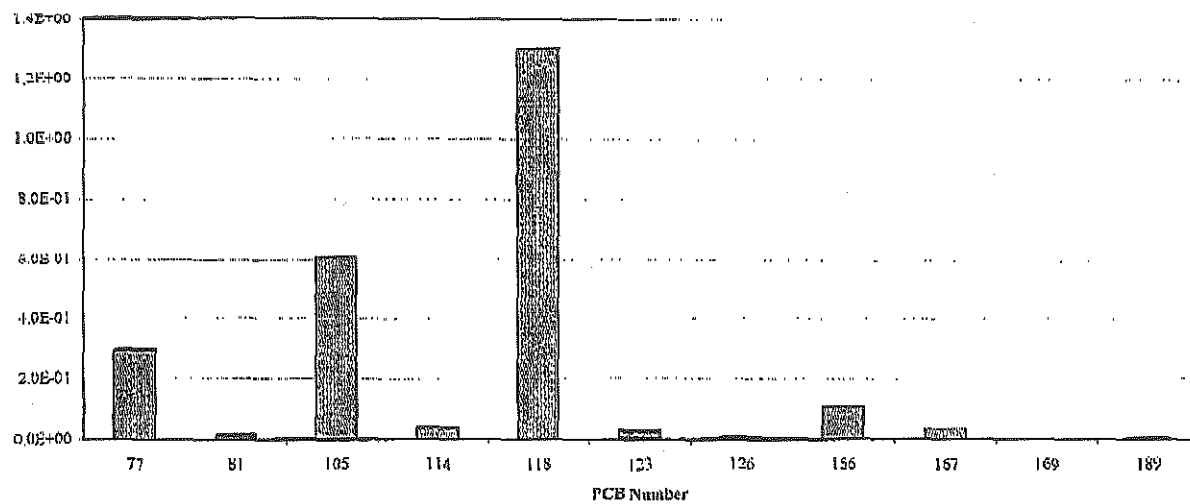
Sample S15



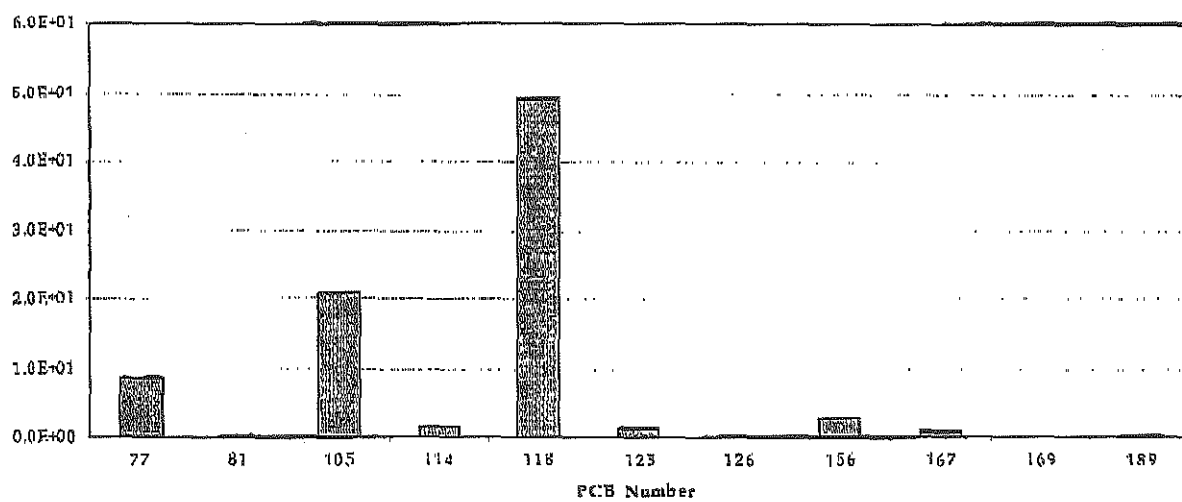
Sample S16



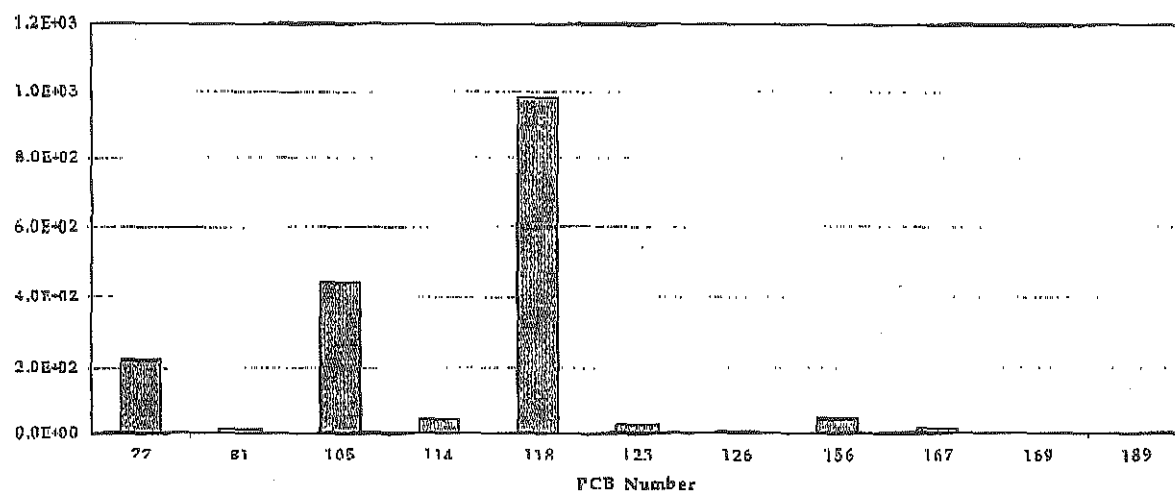
Sample S17

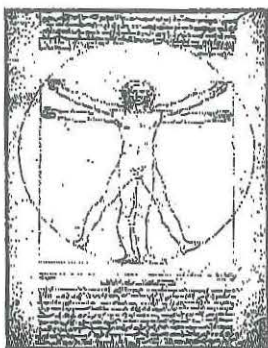


Sample S31



Sample S43





# Scientia Veritas, L.L.P.

5927 Sandrock Drive

Evergreen, CO 80439

Tel: (303) 674-8751

Fax: (303) 674-8755

E-Mail: [REDACTED]

## FACSIMILE TRANSMITTAL SHEET

To: <i>Mr. Mike Mikulka/Dr. Mace Barron</i>	From: <i>Dr. Richard DeGrandchamp</i>
Company:	Telephone Number: <i>(303) 674-8751</i>
Telephone Number:	Fax Number: <i>(303) 674-8755</i>
Fax Number: <i>312-353-4342 270-818-1869</i>	Reference Number:
Date:	
RE:	
Total Number of Pages, Including Cover:	

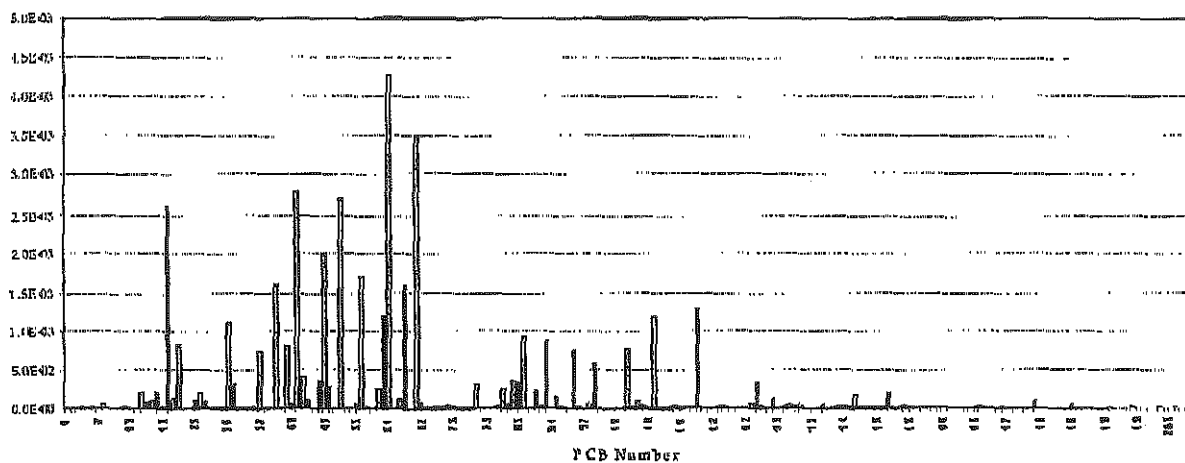
Mes Amis,

Attached is the first set of histograms for the sediment samples showing all 209 congeners. I am still preparing histograms for the subset of 12 dioxin-like congeners and will send as soon as I am finished. Incidentally, Mike-were you able to confirm we can go ahead and start preparing a manuscript for publication? If so, we should schedule a conference call to discuss where we want to submit it. Thanks.

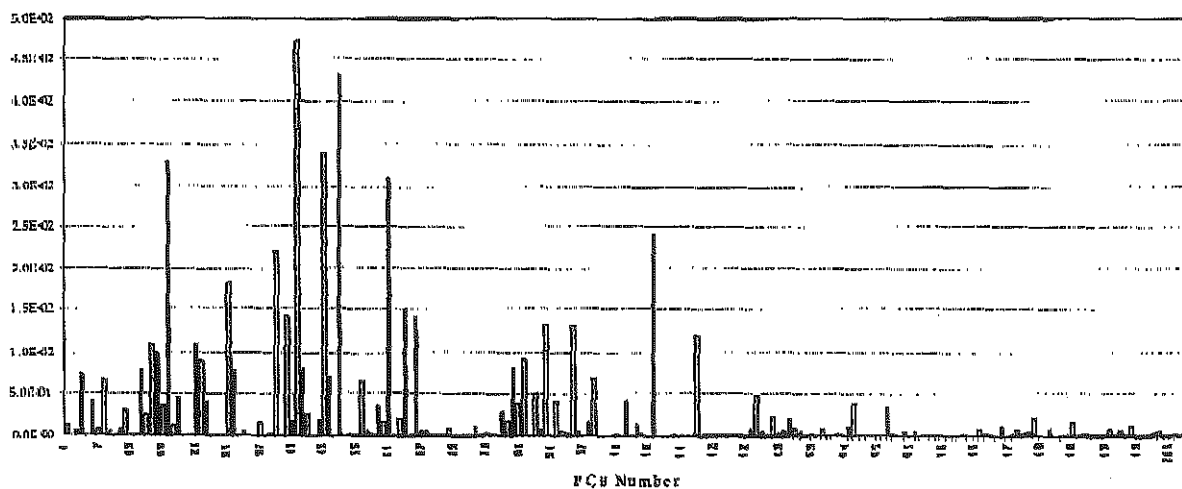
Regards,  
Richard

RELEASED  
DATE 9/21/2018  
RIN # 108  
INITIALS ALG

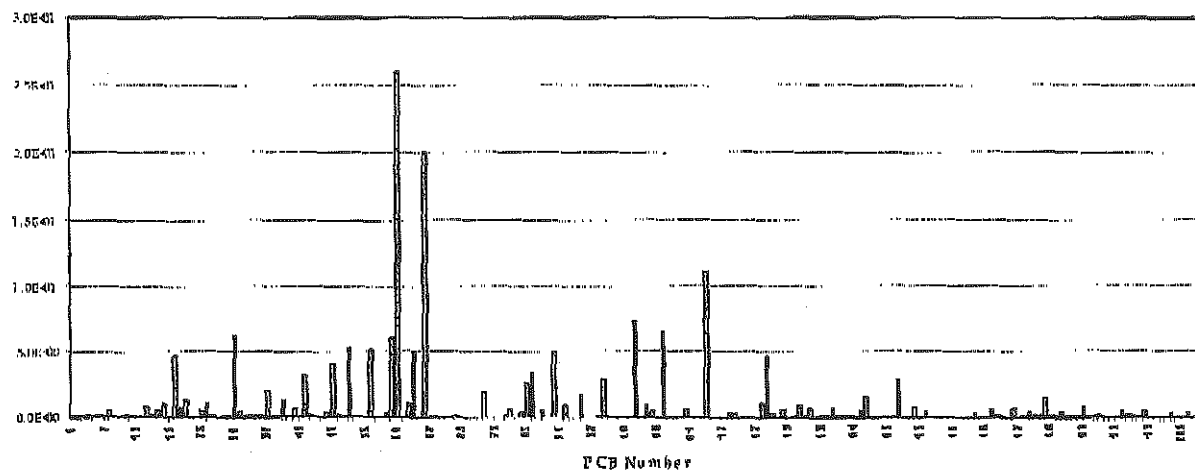
Sample S23



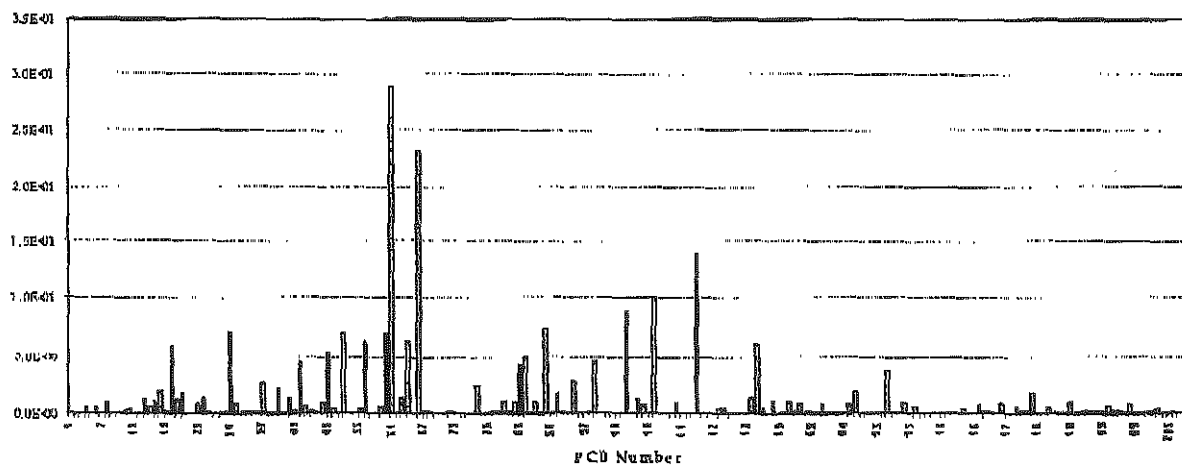
Sample S24



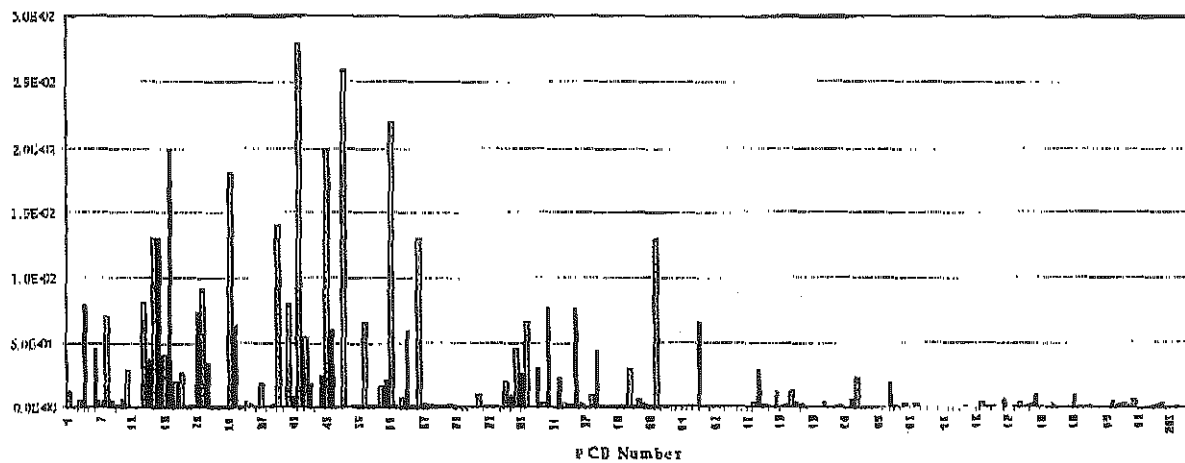
Sample D32



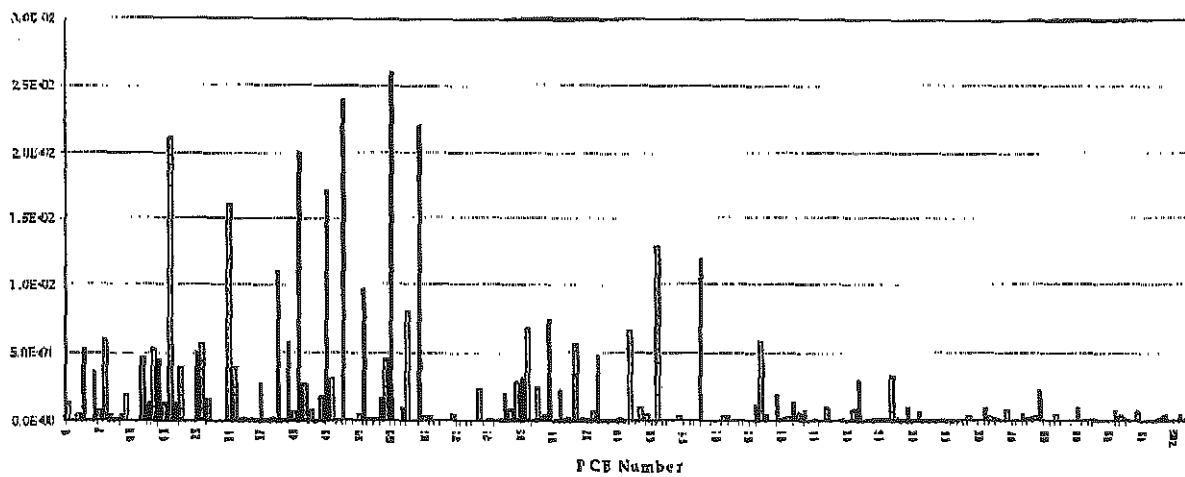
Sample S22



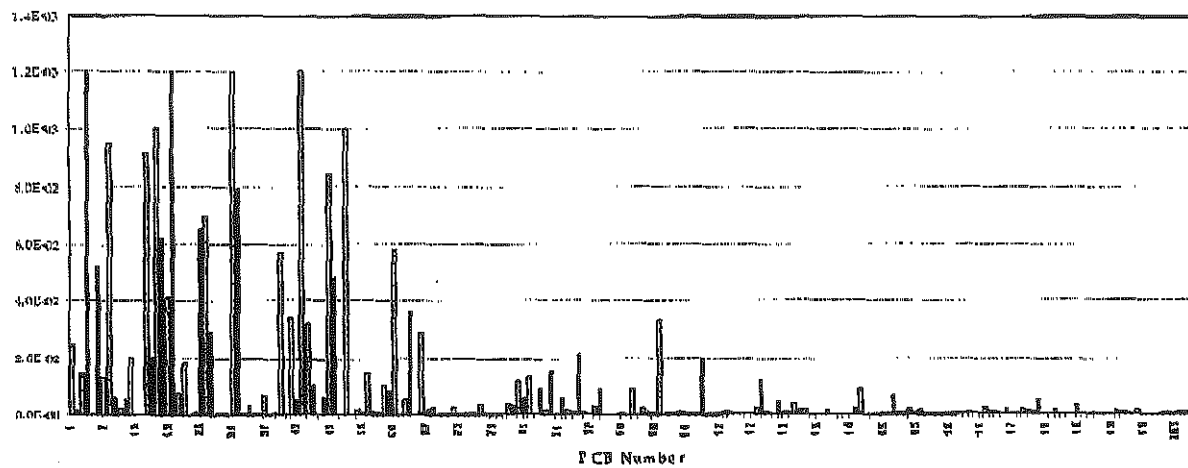
Sample S25



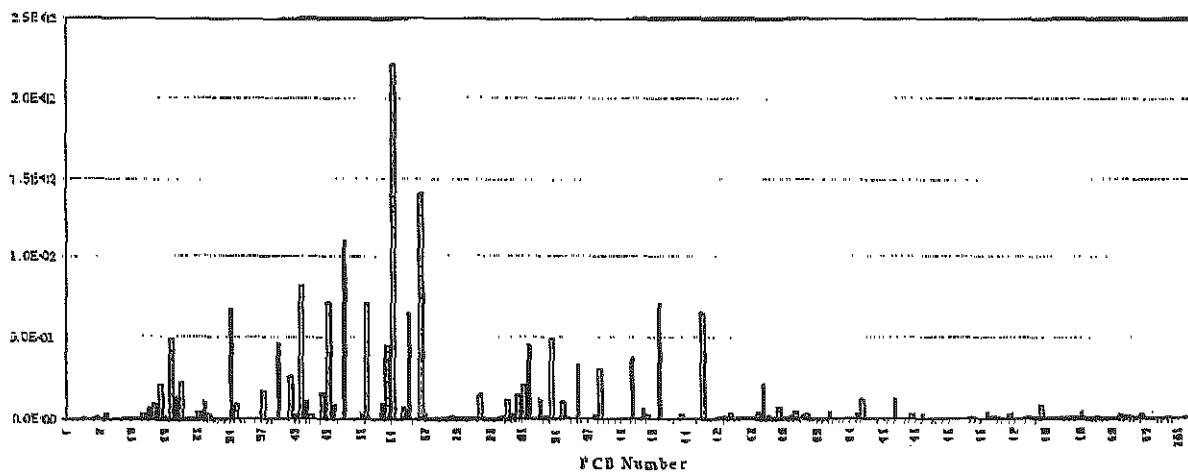
Sample S27



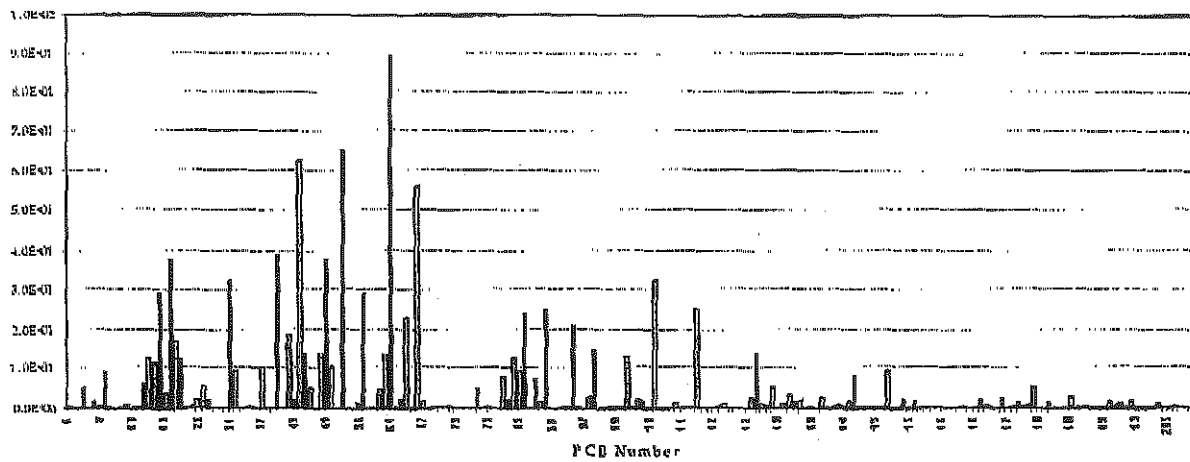
Sample S28



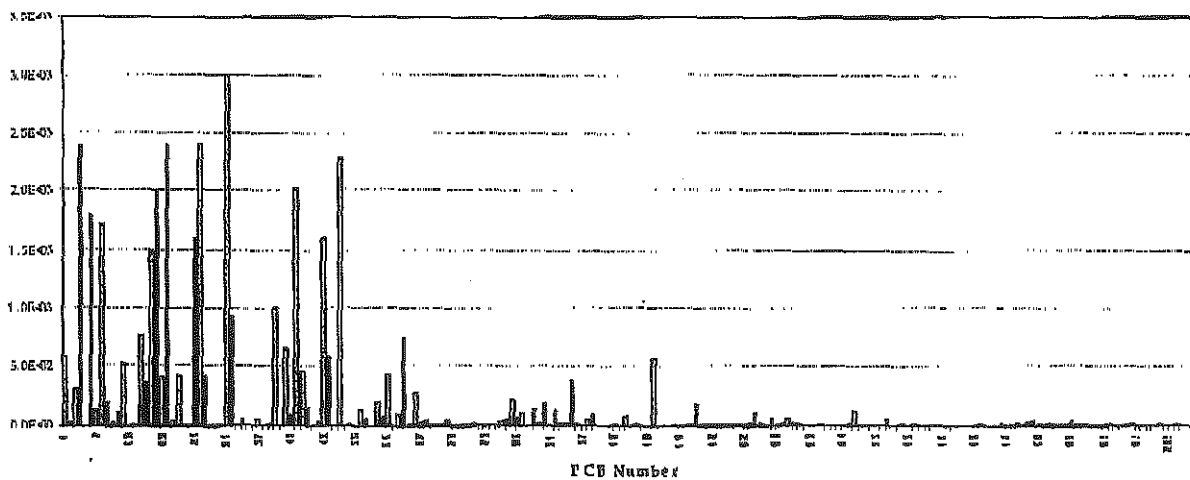
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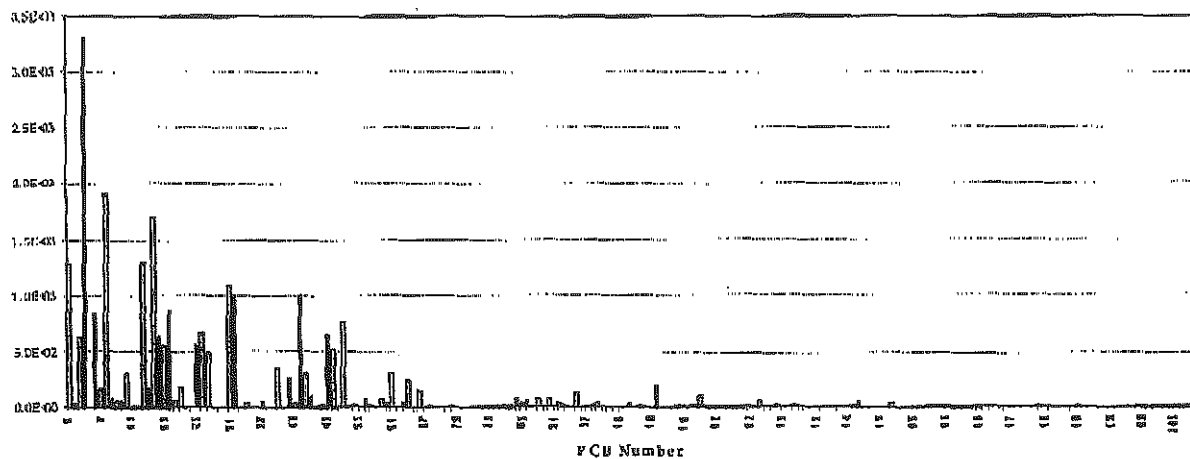
Sample D33



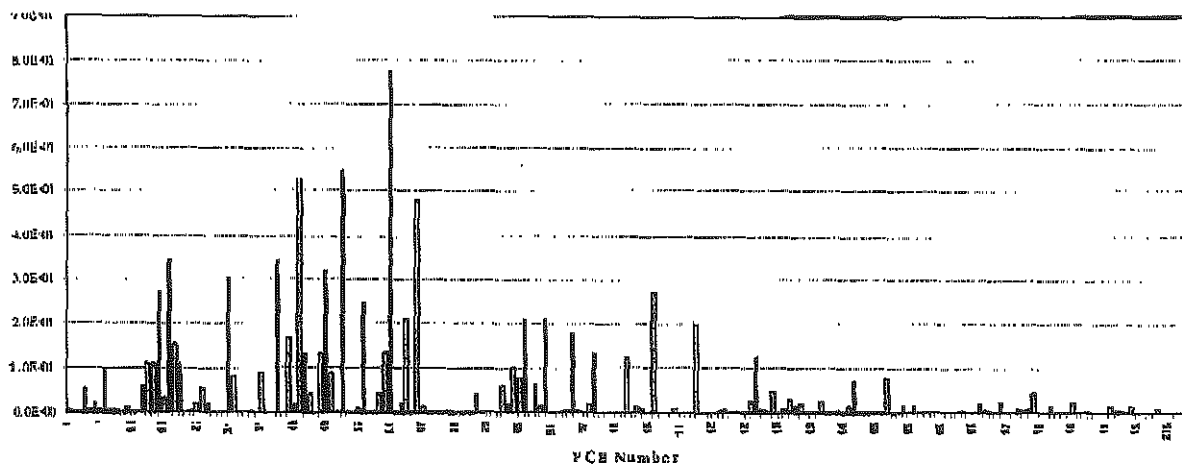
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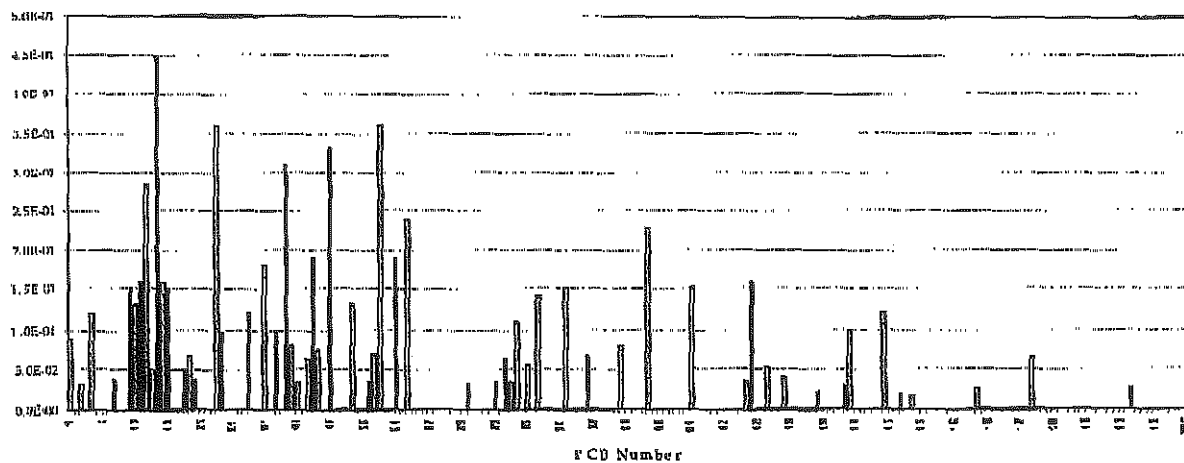
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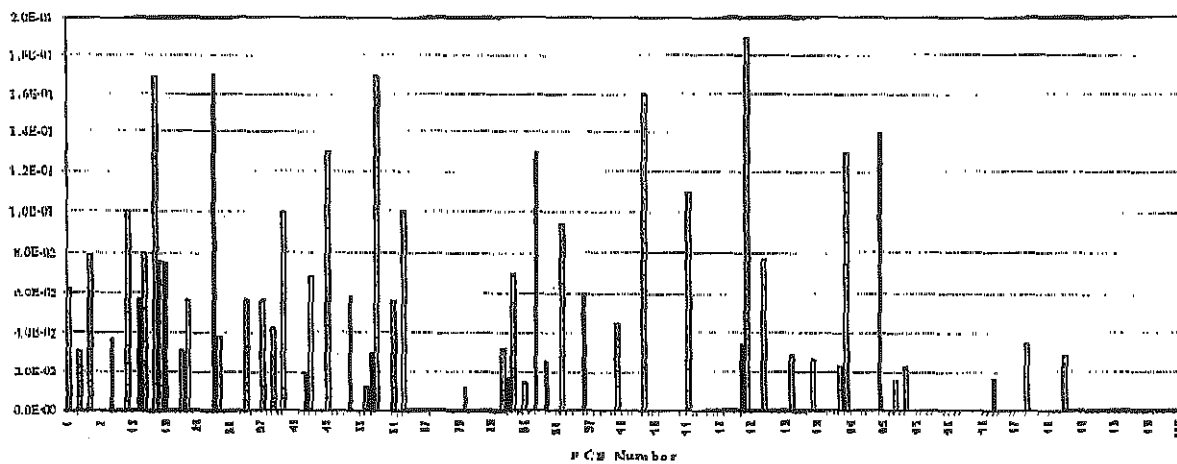
Sample S11



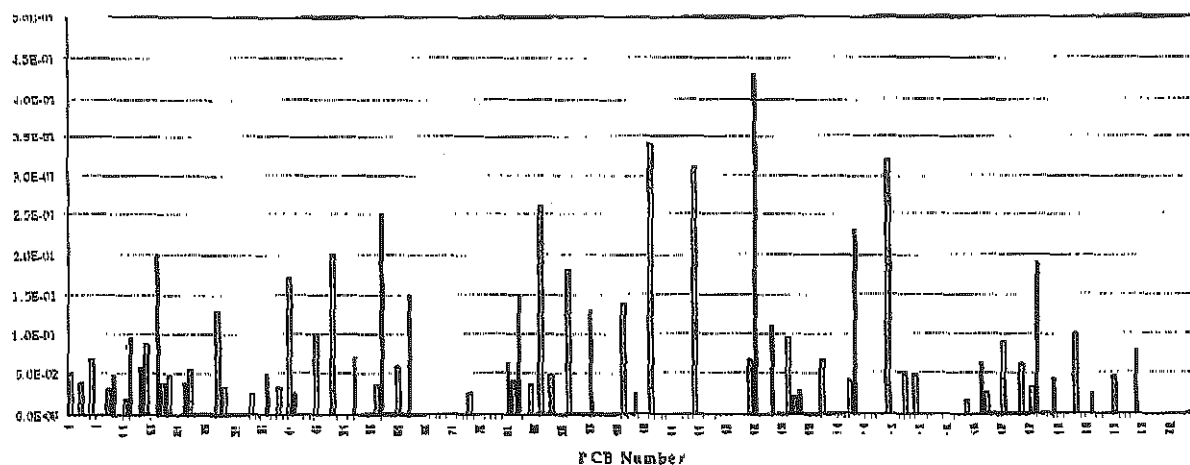
Sample S18



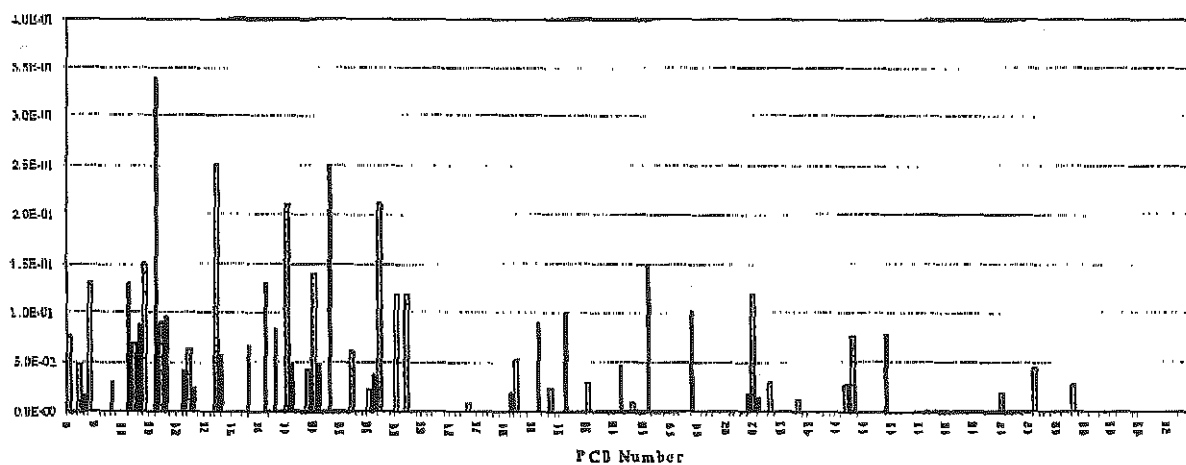
Sample S19



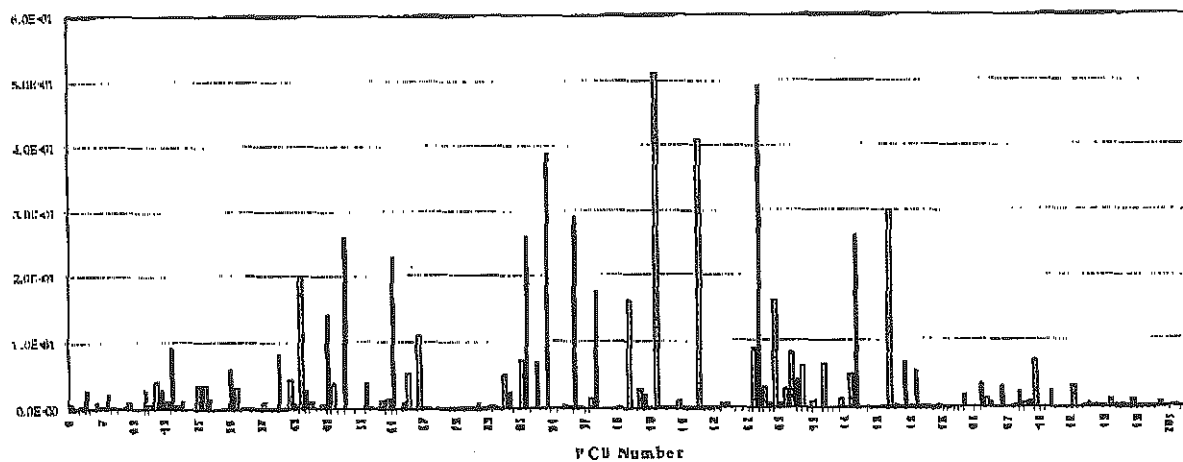
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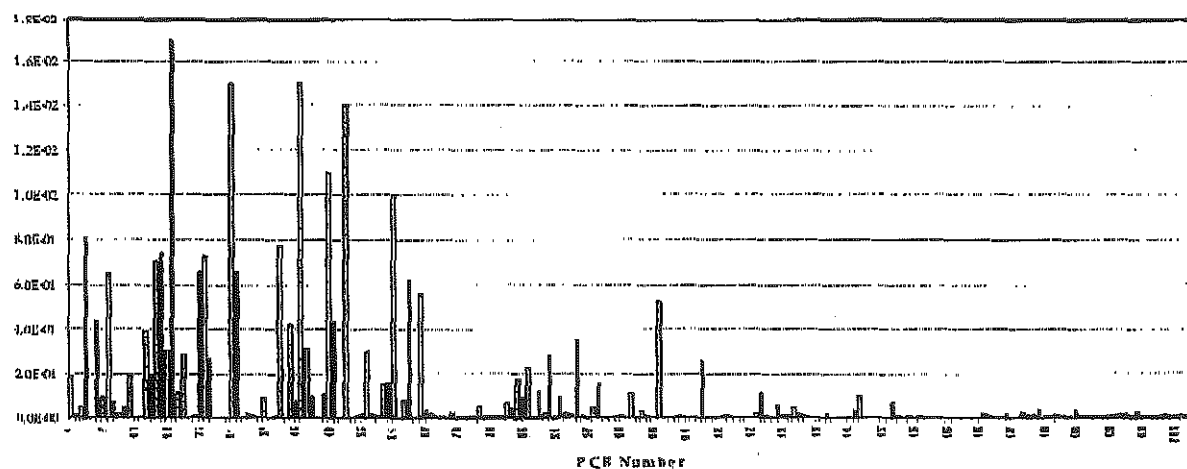
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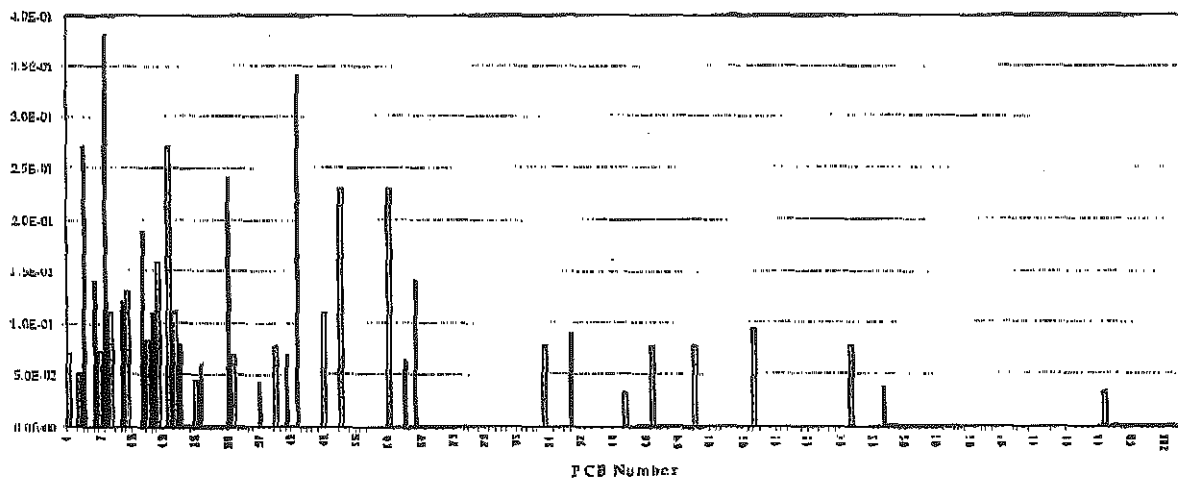
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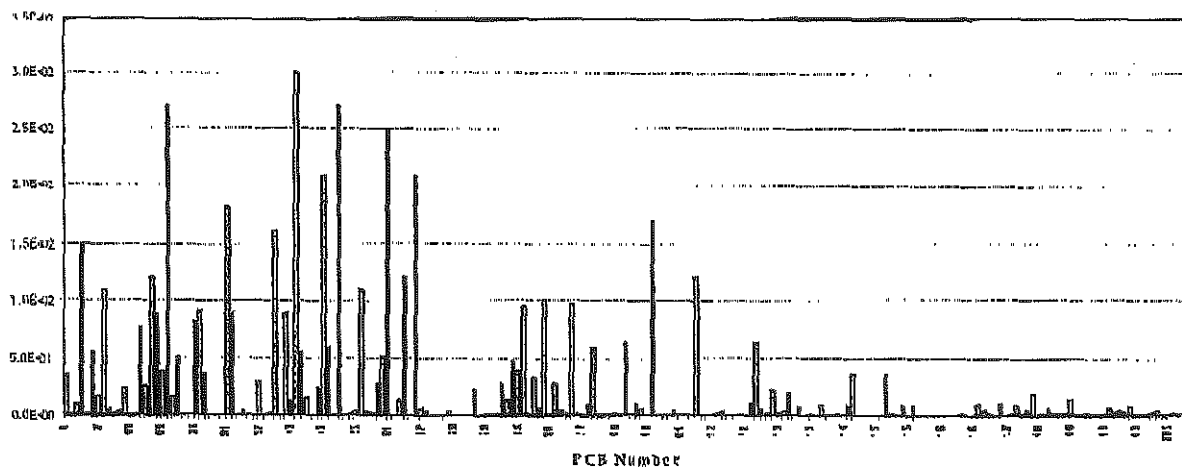
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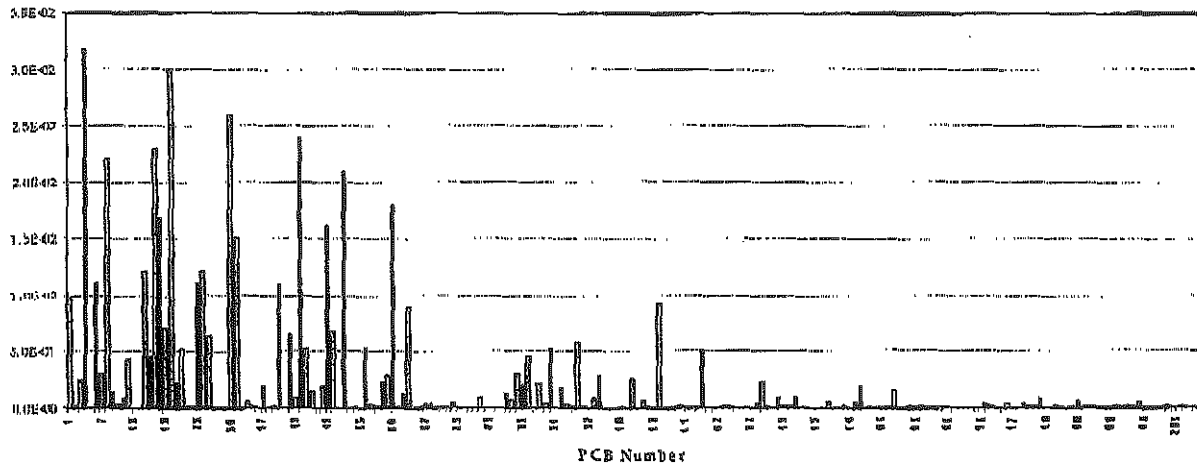
Sample R38



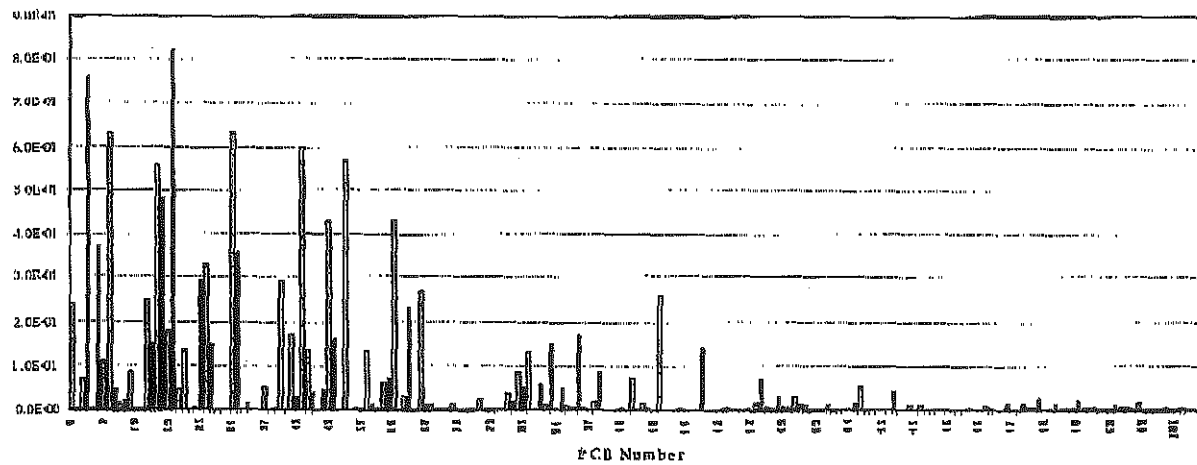
Sample S01



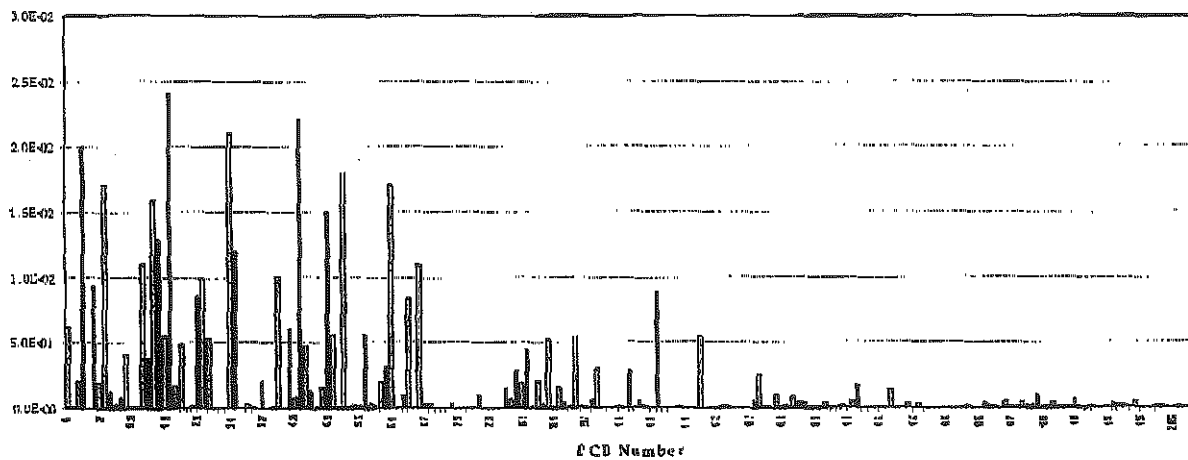
Sample S03



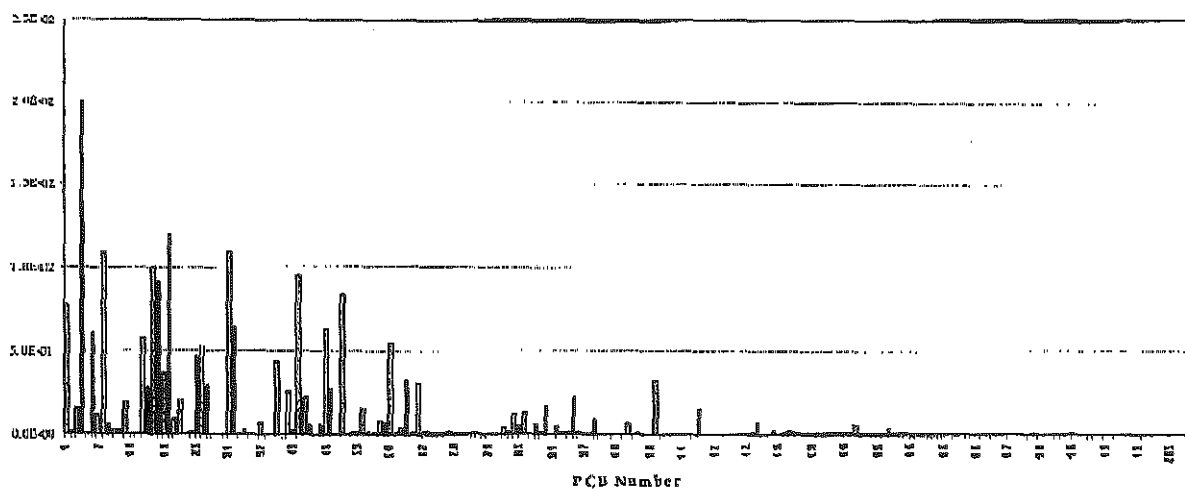
Sample S04



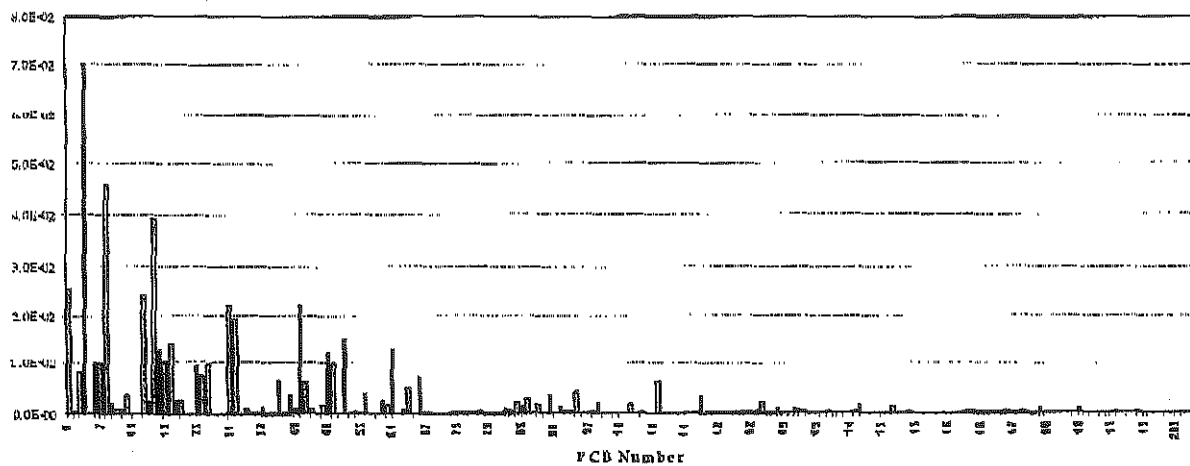
Sample S05



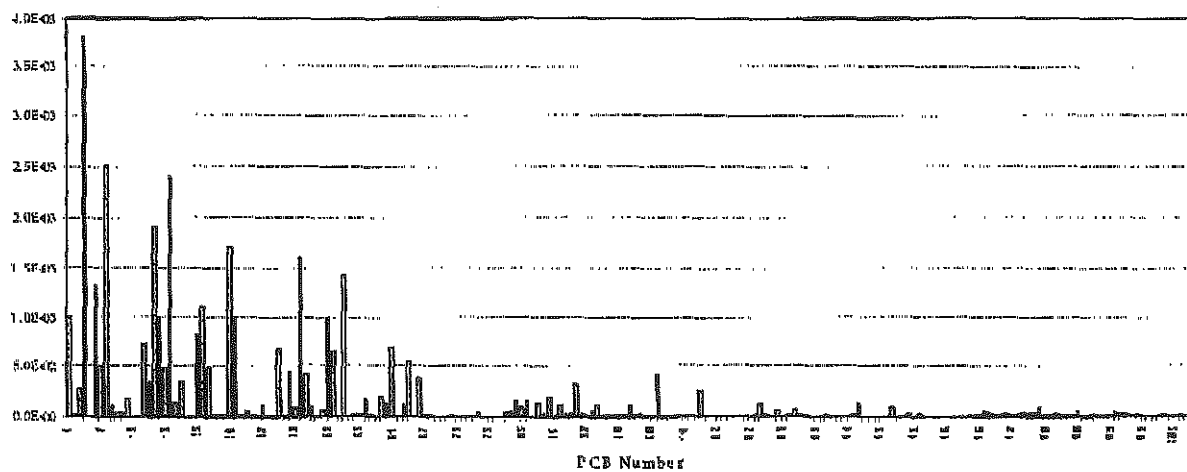
Sample S06



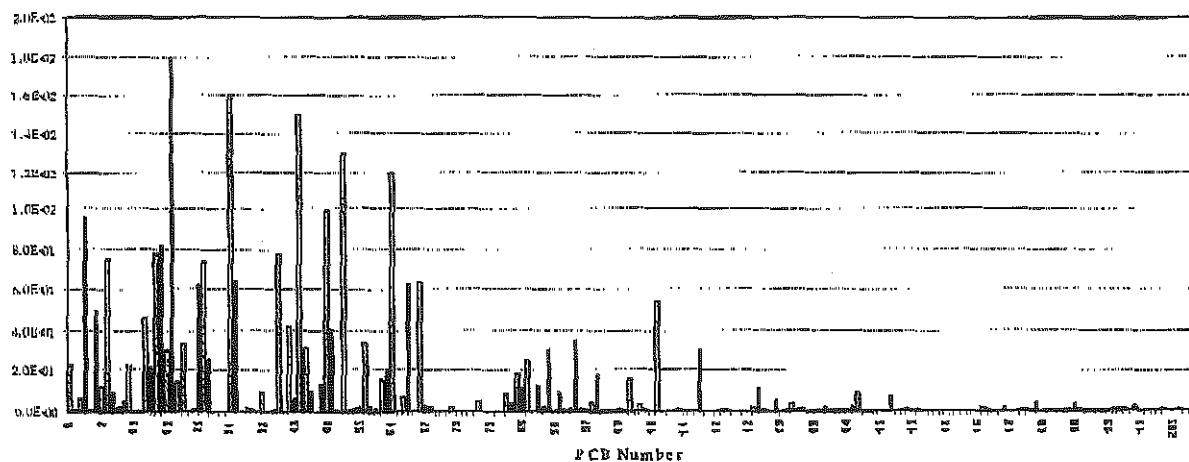
Sample S10



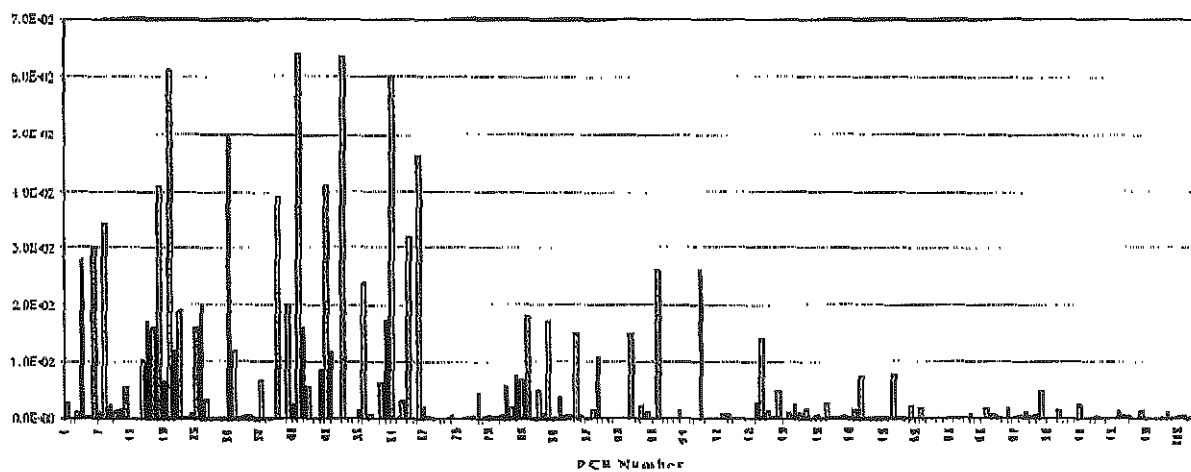
Sample S12



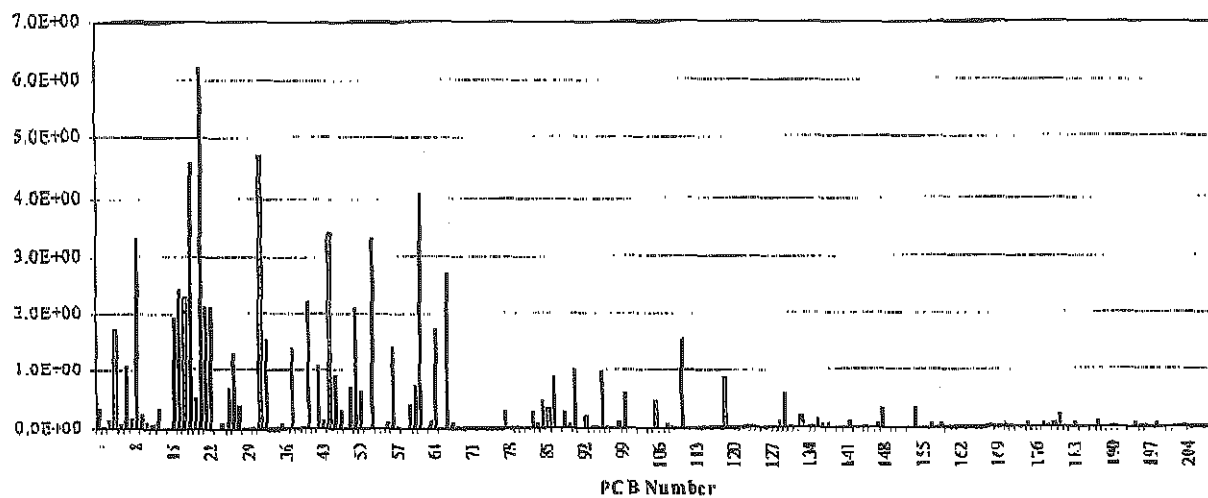
Sample S13



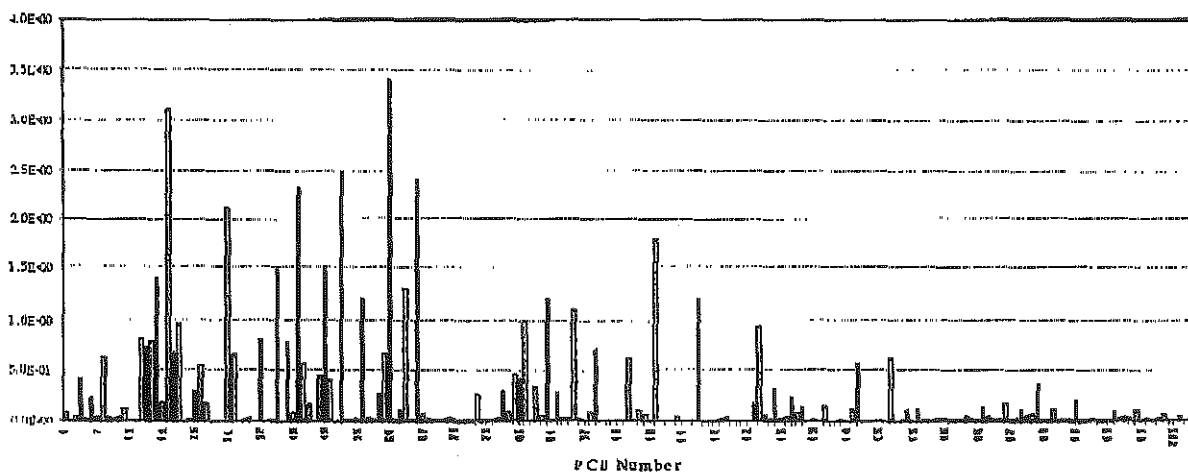
Sample S14



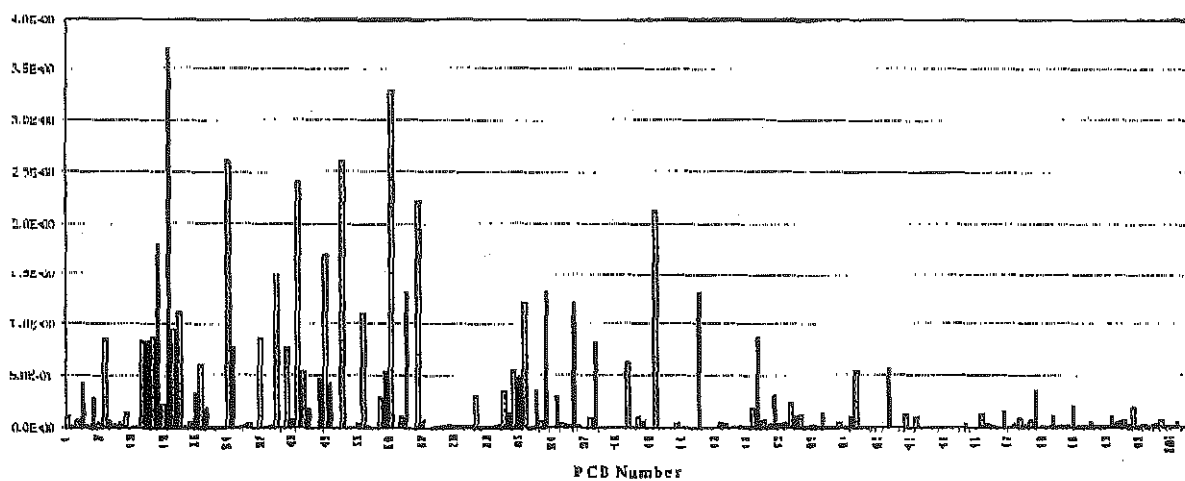
Sample S15



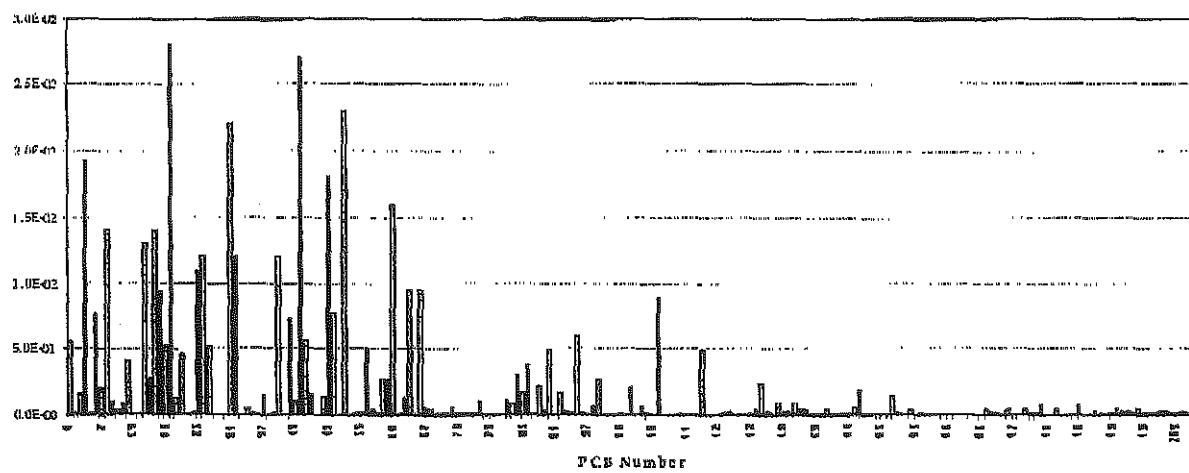
Sample S16



Sample S17



Sample S31



Sample S43

